THE USE OF COMPUTERISED GAMES ANALYSIS TO IDENTIFY CRITICAL INDICATORS OF SUCCESS IN ELITE LEVEL NETBALL

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Declaration

I, the undersigned, hereby declare

that the work contained in this thesis is my own original work

and that I have not previously in its entirety or in part

submitted it at any university for a degree.

Signature:

Date:

Abstract

Netball is a fast and skilful team sport in which players need to be "quick-thinking", because they are required to make fast and accurate decisions in ever-changing situations. Netball is a highly tactical game. Therefore the game has to be analysed on all levels of play. During every game or training session the coach has to look for those factors that influence performance and determine success.

Methods of games analysis have been improved through the development of video and computer technology, in order to help coaches gather critical data. This study will utilise games analysis as a method for gaining insight into what kinds of "critical incidents" on a netball court lead a team to either score a goal, or to allow the opponent to score against them. Four expert coaches analysed game play from three top-level international netball matches in order to identify the reasons for success/failure during game play. A computer-based games analysis system was used to identify the reasons for losing ball possession during the same games analysed by the experts. The results of computer-based games analysis was compared to the analysis provided by elite coaches in order to determine the value of the technology in providing relevant information. These identified key performance indicators were then ranked according to frequency. Additional games statistics were generated, using games analysis. This knowledge will not only contribute to an understanding of how technology can support coaching, but it will also expand our understanding of the tactics of netball and thus contribute to coaches' efforts to teach players how to make "good decisions".

An important by-product of this study was the identification of the key performance indicators that influence success/failure in netball. This knowledge should help coaches determine what kinds of tactical learning situations are important to include in practice sessions. It is the coach's responsibility to develop thinking players. On court - during a game - it is the players' responsibility to read the game and make instant decisions. Also during the game – during time outs and half time- it is the coach's responsibility to give the players feedback on their decision-making and to make suggestions for improvements. Both roles require effective analysis of the game.

Keywords: netball; games analysis; technology

Opsomming

Netbal is 'n vinnige vaardigheidspel. Spelers moet oor die vermoë beskik om in aanhoudende veranderde situasies en spel vinnige, akkurate besluite te neem. Dit is 'n uiters taktiese spel en daarom moet dit op alle vlakke geanaliseer word. Gedurende elke oefensessie en wedstryd moet die aftigter fokus op faktore wat die sukses en prestasie van 'n speler of span kan beïnvloed.

Met behulp van die verbeterde rekenaar- en videotegnologie is verskillende metodes van wedstrydanalises ontwikkel - met die doel om afrigters te fasiliteer om kritiese informasie te versamel. Die doel van hierdie studie is om wedstrydanalise as 'n metode te beskryf om kritiese situasies te identifiseer wat tot gevolg het dat 'n span 'n doel wen of afstaan. Vier topvlak afrigters het drie internasionale wedstryde geanaliseer om sodoende die redes vir sukses of mislukte pogings in die wedstryd te identifiseer. In dieselfde drie wedstryde is 'n rekenaar wedstrydanalise stelsel gebruik om die redes vir balbesit of –verlies te identifiseer. Die resultate van die rekanaar-gebaseerde spelanalises en die vier afrigters is vergelyk om die waarde van die verskil in informasie te vergelyk en te bepaal. Die kern prestasiefaktore wat deur bogenoemde geïdentifiseer is, is volgens rangorde geplaas op grond van die frekwensie waarop dit voorgekom het. Hierdie inligting sal as 'n bydrae dien tot die wyse waartoe tegnologie afrigting kan ondersteun. Dit brei ook die verstaanbaarheid van taktiek in netbal uit en bevorder besluitneming meer spesifiek.

'n Belangrike resultaat van die studie is die identifikasie van die kern prestasiefaktore. Hierdie inligting kan afrigters in verskeie taktiese leer-situasies ondersteun. Die ideaal is dat elke afrigter sy verantwoordelikheid sal besef om onafhanklike, selfdenkende spelers te ontwikkel. Op die baan is dit gevolglik die speler se eie verantwoordelikheid om die wedstryd te lees en besluite te neem. Gedurende halftyd en na die wedstryd is dit die afrigter se verantwoordelikheid om aan spelers terugvoering te gee, asook aanbevelings te maak ten opsigte van besluitneming. Beide rolle, as afrigter of speler, vereis effektiewe wedstrydanalise.

Sleutelwoorde: netbal; wedstrydanalise; tegnologie

"The journey is the reward"

Lisa Carruthers

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Chapter 1

Setting the Problem

Netball is a fast and skilful team sport in which people of all ages and levels of ability can participate. All seven players have important parts to play in their own limited area where they operate (Appendix A). The team needs to work together to attack and score goals as well as to defend and prevent their opponents from scoring. According to Crouch (1992), these actions demand a variety of skills as well as the ability of each player to be selective in the use of the skills, so as to produce a flowing game. Players need to be "quick-thinking", because they are required to make fast and accurate decisions in ever-changing situations.

As a fast-moving dynamic game, netball presents the players – whether on attack or defence – with a variety of problems to solve. In other words, netball is a highly tactical game. Defensive and attacking patterns can change many times during a game. Good coaches try to help players become more tactically aware and to be more effective decision-makers. A team that understands the strategic principles of netball and the specific game strategy of their coach should be able to apply their understanding to the tactics of that specific game (Galsworthy & Harrison, 1999a). A coach cannot provide training that can prepare players for all possible game situations, but she can teach the players the strategic principles of play and design sessions where the players practice applying those principles to game play. These practice sessions must simulate realistic game situations in which players learn how to make tactical decisions.

The emphasis on the learning of tactics – of making strategic decisions while playing – is encouraged in the "games for understanding approach" for learning sports (Thomas, 1997). Players on offence learn to watch each other as well as the defenders in order to decide who should make what move and when. The player who makes the move has to use all the space available and should move positively (Batty, 1994). Just as a coach should encourage her attacking side to keep the ball in play, she should encourage her defending side to keep the ball out of play. Defending players can deny space to the attacker and therefore reduce the attacking options. Defenders can use different strategies

to close down the space available to the attacker (Batty, 1994). Other defensive tactics include:

1. Defenders learning to position themselves so that the attacker is forced to play within a small area of the court.

2. Defenders learning to position themselves so that the attackers cannot get to the space where they want to go. For example, when defending inside or close to the shooting circle, the defenders know that a shooter wants the ball under the post.

3. Defenders learning to work together to limit the space available to the attackers. The result of these different strategies is that the interception possibilities increase.

4. Defenders learning how to "close down space". By applying pressure to the attackers, the defenders reduce options for passing, thus, closing down space and making it difficult for the attackers to make decisions (Galsworthy & Harrison, 1999b:18).

In order to apply the games for understanding approach successfully, the coach herself must understand the interaction between offensive and defensive actions. When the coach makes decisions in a game about the method of defence, she should base her team's analysis on her analysis of the game compared to the ability of her players and their capability to take advantage of the weaknesses of the opposing team. Just as the player who throws the ball away in the same situation several times distracts from her team's performance, so too does the coach who cannot understand why players keep repeating an action or why a certain action that worked once does not necessarily work a second time.

Both coaches and players need to learn how to analyse game situations and apply their understanding of the strategies and tactics of netball. According to Broomhead (1989), a coach can apply the following thought processes during a game:

Identify the problem	WA and C keep feeding the GS who is double-marked.
Why do they do it?	Possibly because as they land with the ball, the decision to pass the ball to the GS has already been made and processed, therefore the throwing action to produce this result has already been initiated.

Result	A pass is forced to the GS, which is intercepted, or the GS fumbles, because she knows it was the wrong pass; or the thrower tries to stop her action and produces an ineffective pass to someone else.
Solution	1. Help is needed with the technique of changing the player's mind at the last second about the direction or the type of pass. 2. Help is needed with the assessment required to enable the player to change her mind and focus.

In order to engage in this kind of "game thinking," the game of netball must be carefully analysed on all levels – from the beginner to the elite player. The need to be a body of knowledge created about the interaction of offensive and defensive tactics that both coaches and players can study and explore within their practice sessions. As this body of knowledge grows in sophistication, it must also be updated continuously as coaches design new ways of mobilising their players for success, as technology changes, the circumstances surrounding game play, and as rule changes alter the tactical situations in games.

The importance of tactical learning in netball has a major impact on how netball is coached. Coaching netball demands a mind-set that can deal with constant change and is open to collaboration with players and technical experts who bring insight into how the game is played. A netball coach must not only be organised in a systematic way, but must also be determined to utilise on-going evaluation to modify or even re-structure her system. Accurate analysis and measurement of both the physical and tactical aspects of performance are necessary to produce the feedback needed to improve players' performances. In the past, the evaluation process used to generate this type of feedback process followed a sequence similar to this:

1. The coach watched a game carefully.

2. The coach then identified the positive and the negative aspects of the team's performance, as well as each individual player's contributions.

3. The results of the coach's observations and conclusions were taken into account when designing future practice sessions and determining the strategies for the next game.

4. The next game was played and the process would repeat itself.

The current level of sophistication in sport and the availability of technology have changed the way in which successful coaches operate (Sports Coach, 1996). Although the modern coaching process still requires the ability to assess situations, apply coaching principles and evaluate actions, the process for gathering information on which to base these actions has become more systematic.

1. The coach must first assess the need for action. This involves gathering both objective and subjective data that enables the coach to identify each player's strengths and weaknesses, as well as any team strengths and weaknesses.

2. Specific objectives are set and a plan of action prescribed to help each player and/or team to achieve these objectives.

3. After the plan of action is implemented, the last step is to evaluate the results of the action. This provides feedback about the coaching plan that allows the coach to make adjustments as needed in her coaching actions.

Gathering information has become more systematic because more is expected from coaches. Coaches are not evaluated according to how they perform, but rather according to how well players perform as a result of their coaching. The coaching process is dynamic, organised and systematic, but it has also become "deliberate" (Fairs, 1987). The modern coach plans carefully, evaluates precisely and focuses all her resources on improving the performance of her players.

During every game or training session the coach looks for those factors that influence performance and determine success. Progress has been made in the development of technology to assist the coach in measuring player performance in order to identify these factors. For example, technical devices like the electronic jump mat allow coaches to measure each player's vertical jumping strength/leg power in order to make specific recommendations for fitness training. Within this more sophisticated and systematic approach, coaches are also using "games analysis" to help them gather critical data. Games analysis is a form of systematic observation and evaluation of game play that has become an integral part of describing game performance (Winkler, 1997).

The increased interest in research in games analysis is based on its link with decision- making - the ability to make quick and accurate tactical decisions in team sports. Situations in team sports change fast and continuously, thus team sport requires a great number of tactical decisions by players to attain a high level of performance. In research completed by Tavares (1997), the effect of experience on the quality and quickness of tactical decision-making time was studied, using computerised techniques. Players had to select the correct tactical alternative (pass, dribble or shoot) and respond by pressing a pre-selected key on the keyboard connected to the video computer. The quality and speed of a player's decision-making during play depend on factors such as speed and accuracy of information reception, tactical knowledge, skills and experience. The quality of information reception also depends on the players' visual skills. The results showed that expert players made quicker and more accurate decisions in technical – tactical situations than novice players. As players become more skilful the decision-making process becomes faster and the performance of the tactic or game plan is more successful.

Methods of games analysis have been improved through the development of video and computer technology. Players can now watch their own game performance on videotapes and learn to identify their own tactical mistakes in different situations. These developments in computers now allow a coach to identify specific game situations that can be played back on videotape and evaluate statistically what has occurred in a specific situation or game. Video images can be digitalised and stored on a hard disc for future use. Computer technology can be used to edit any video presentations and computer graphics can be combined with video clips to create attractive teaching or presentation videos. These advances in technology have made the use of computer-assisted games analysis one of the "growing edges" in modern coaching.

Significance of the Study

For the modern coach, knowledge of how to teach the basic motor skills (landing, pivoting and changing direction, stopping, throwing, catching and shooting) needed in netball, remains important. It is equally critical to teach players the basic tactical skills of getting free, marking and intercepting, which involves helping players develop a spatial awareness of themselves, the court and the players from both teams. These skills have to be learned and then applied in game situations. One of the principles of attacking play, for example, is for players to move in such a way that they "open up space" and then "use that space effectively" (Galsworthy & Harrison, 1999b). Beginners, however, have the tendency to follow the ball and gather around the person with the ball. During game play the coach must constantly remind them of their responsibility to open up space and to keep their position.

This study will utilise games analysis as a method to gain insight into the kinds of "critical incidents" on a netball court that lead a team to either score a goal, or to allow the opponents to score. The results of computer-based games analysis will be compared to the analysis provided by elite coaches in order to determine the value of the technology in providing relevant information. This study can also help with the identification of the additional games statistics that can be generated by using games analysis. This knowledge will not only contribute to an understanding of how technology can support coaching, but it will also expand our understanding of the tactics of netball and thus contribute to coaches' efforts to teach players how to make "good decisions". No coach can help her team achieve its potential without a comprehensive understanding of how the dynamic relationships among offensive and defensive actions directly lead to either side scoring points.

Research Questions

The following four research questions were used to guide this study:

1. What are the critical indicators of success/failure in game play in netball, according to analysis by elite coaches?

2. What are the critical indicators of success/failure in game play in netball, as identified by a computer-based games analysis system?

3. What is the relationship between the information generated by elite coaches and that generated by computer-based games analysis?

4. What additional game statistics can be generated using games analysis?

Limitations

- During this study the researcher used the expertise of four coaches in order to identify the critical indicators. The researcher could get a broader perspective by using more expertise.

- Each coach could select a critical incident, of her own choice, during a game and decide when the researcher had to stop the videotape. After identifying the critical incident, the coach could classify it herself.

- During the computer-based games analysis the researcher classified the loss of ball possession situations according to her own knowledge.

- The computer program used for this study meets the requirements for the purpose of this study, but could include limitations for other events or studies.

- A limited number of games were analysed.

Definitions

Skill

A range of motor tasks also described as the quality of performance. Technique and pressure form skill.

Technique

Technique can be described as the movement itself - when a player sees the need and when it is appropriate to use it.

Tactical awareness

The ability to identify tactical problems and their solutions in game situations.

Games analysis / Match analysis

It is the process of really seeing what is happening at every instant of the game.

Game sense approach

An approach to coaching that uses games to develop tactical or strategic thinking, as well as skill development (Den Duyn, 1996). It includes the necessary action.

Notational analysis

A technique that records every movement or action by every player during every match.

Key performance indicators

The main factors that lead to winning or losing in high-level competition.

Summary

This study demonstrates the advantages of using computer-based games analysis as a tool in modern netball coaching. Computer-based games analysis was used as a method to identify those "critical incidents" on a netball court that lead a team to either scoring a goal, or to allow the opponents to score against them. The results of the analysis were then compared to the information about game play gathered from elite coaches, in order to determine the validity and uniqueness of the information generated, using games analysis. The kinds of additional game statistics that can be generated, using computer-based technology, are also demonstrated.

An important by-product of this study was the identification of the critical incidents that influence success/failure in netball. This knowledge should help coaches determine the types of tactical learning situations that are important to include in practice sessions, as well as to identify what game situations are the most productive or most dangerous for their team. It is the coach's responsibility to develop thinking players. This is accomplished partly during practice sessions. On court - during a game - it is the players' responsibility to read the game and make instant decisions. During time outs and half time the coach should give the players feedback on their decision-making and make suggestions for improvements. Both roles require analysis of the game.

Adopting a "games for understanding" approach means that practice sessions will be utilised to develop thinking skills as well as motor skills and physical fitness. Each player needs to learn how to play while making an on-going evaluation of the strategic situation on court. The player should then combine her understanding of the game and decision-making skills that lead to the correct movements on court. Coaches need to help players learn to read the game "two moves ahead." Players should be given time to practise how to observe and select the most appropriate tactic. Although it is still the players' responsibility to make the correct decisions during game play, these decisions will be based on the principles of space, time and interrelationships with the movement of the ball and the players that have been learned during practice sessions (Verroken, 1985).

Chapter 2

Review of Literature

Coaches are responsible for the development of players in a variety of ways. In a team sport, for example, the coach has an obvious role as the leader who organises and directs the team. However, the coach is also responsible for observing and evaluating each player's game performance to plan and conduct practice sessions that will help each player as well as the team to improve. To provide this level of technical support, the coach must learn to assess, apply and evaluate strategies and tactics in a competitive surrounding. Modern coaching has been described as a process that is as much concerned with defining and analysing problems as it is with solving them (Fairs, 1987).

The Responsibilities of a Coach

Crouch (1992) has identified five different roles that a coach must be prepared to accept in order to help develop the maximum potential within every player and team:

Teacher

It is difficult to completely separate coaching from teaching. Early literature on coaching made it clear that, in order to be a good coach, you must first learn to be a good teacher (Sabock, 1979). Although the role of coach and teacher may overlap, current research tends to study them separately because of the definite differences between them. Rupert & Buschner (1989), for example, found that praise, scolding and hustling are used more frequently when coaching at a practice session than when teaching a physical education class. They also found that teaching involves much more group management than coaching.

Organiser

Organising the training programme and practice schedule for a team and all the individual players is very demanding. Some coaches also have to organise the activities of support staff.

Disciplinarian

Coaches are responsible for setting and maintaining a productive learning environment. Players will be able to improve at optimal rates only when a sense of focus and accountability is maintained.

Psychologist

The ability to "motivate" individuals and teams to achieve, is frequently identified as one of coaches' major responsibilities.

Diplomat and public relations officer

Coaches are often "in the public eye". They commonly work with parents as well as members of the community. On the top level, coaches may represent their regions and even their countries at international competitions. This level of interaction with the public and the media requires that coaches must be prepared to be held accountable for their actions and their comments.

From these five broad descriptions of the roles of a coach, the role of teaching – or more specifically "providing instruction"- has been identified as the most frequently occurring responsibility among successful coaches (Segrave, & Ciancio, 1990). Successful coaches strive to provide players with enough knowledge, technique development and information to improve their individual skills and game performance. In their study of coaches' strengths and weaknesses, Weiss, Barber, Sisley and Ebbeck (1991) found that one of the most highly rated strengths of a good coach is "knowledge of the game," which include knowledge of the whole sport as well as the subtleties involved in training and competitive performance. One of the most frequently identified areas of coaching weaknesses was the lack of knowledge and skills, which was defined as the inability to teach sport-specific skills/techniques and game strategies. When Lacy and Darst (1985) observed the behaviours of successful high school football coaches they found that instruction was used during every phase of the season. During the pre-season, coaches focussed on teaching basic and individual skills. Throughout the rest of the season, coaches focussed on teaching game strategies and tactics.

Differences between advanced coaches and beginner coaches

In a study of the differences between instructional behaviour of elite and beginner coaches, Jones, Housner and Kornspan (1997) found that both experienced and inexperienced coaches were active teachers. Both groups of coaches indicated that they preferred practice sessions that proceed according to plan, but inexperienced coaches found it more difficult to adapt if problems occurred during a session. This may be because inexperienced coaches do not have alternatives available to implement in order to adapt to circumstances as they occur. Experienced coaches also appeared to have developed the skill of analysing performance situations automatically. This may explain why they have displayed more technical instruction during practice sessions than the inexperienced coaches.

Jones, Housner and Kronspan (1997) also found that both experienced and inexperienced coaches display frequent periods of silent observation. Experienced coaches were diligent planners, taking more time to plan and expressing more confidence in the effectiveness of their plans. Experienced coaches paid more attention to information cues about the skill levels, abilities and characteristics of players than inexperienced coaches. They also established objectives for the practice session; developed instructional methods designed to facilitate the achievement of objectives, and designed strategies for evaluating players' attainment of objectives. Like experienced physical education teachers, experienced coaches constructed contingency plans that could be implemented, should problems occur during practice. In contrast, inexperienced coaches' planning was limited to superficial and narrow concepts. Their plans were limited in terms of the number of goals, without considering the number of players, players' ages, or ability levels.

When examining coaching expertise in the context of memory models, knowing more about a specific subject, implies having more schemas of concepts stored in the memory, as well as having more linkages between the schemas and concepts. This approach would suggest that the ways in which expert and novice coaches represent information in their memory structures might differ. Experts in all fields have a better ability to recognise situations and patterns, to recall information, as well as to organise information in their minds. Expert teachers or coaches have a few instructional routines, but the routines are flexible. Experts request more information while planning a session and they are more able to make decisions about management of the activities before the

session, which means that they can anticipate problems and thus avoid some problematic situations. Experts have also been found to be better at anticipating critical moments in a lesson, and creating contingency plans for these situations. In other words, experts can make "in-flight decisions", which in contrast, is a very difficult task for novice coaches (Byra & Sherman, 1993).

It seems that novice coaches lack sport-specific knowledge and confidence in their coaching ability (Weiss, Barber, Sisley & Ebbeck, 1991). Ahlgren, Housner and Jones (1998) did a study to compare 10 experienced high school and 10 inexperienced junior high and middle school basketball coaches during practice. The coaches were provided with a 30-minute planning session to coach a 30-minute practice session. Definite differences were found between coaches. Experienced coaches expressed more confidence in their plans. They determined objectives for the practice sessions and developed instructional methods to achieve objectives and afterwards strategies to evaluate objectives. In contrast, inexperienced coaches' planning was limited to generating activities. It seemed like they were trying to keep the players busy. During coaching performance, they did not seem to take into account the number of players, their ages or their ability levels when selecting activities. Inexperienced coaches focused on players' engagement rather than skill acquisition. The performance of experienced coaches, on the other hand, was characterised by the use of demonstrations, instructional cues, well-organised instructional tasks and skill-related feedback.

Aspects of coaching advanced players

Logic dictates that elite level players need advanced coaches who have the expert knowledge and skills needed to help them achieve top-level performance. According to Sabock (1979), there are many qualities that a coach should have in order to be good at a high level. These skills include:

The ability to recognise talent

The ability to utilise the talent available

A comprehensive knowledge of the sport

According to Sabock (1979), the key to successful coaching is a carefully organised programme of training and competition that leaves little to chance. This planning stage is

dedicated to designing the most effective and best way to get maximum performance. The nations that finished in the top ten at the 1972 Munich Olympic Games, for example, had national sport development plans. The success of these nations was attributed to talented athletes working within a progressive, long-term programme. Many factors like changes in time, money, facilities, competition, climate, attitudes and beliefs of players and coaches, etc., will undoubtedly affect any coach's plan and will call for modifications in the plan. Even with this recognition that modifications will be necessary, carefully planned training and competition provide a stable environment in which athletes can feel secure and strive to do their best (Daly and Parkin in Pyke, 1997).

Effective planning relies on the coach's ability to identify and understand the important information. Information can be gathered from a number of sources, however, the most critical source of information for top level performers may be the observation of play at games and practices. The coaches' reasons for observing game play have to be specific and clear. The coach must know what he wants to observe and why. A checklist can be very helpful. Films and videotapes are valuable tools because actions can be stopped and repeated for analysis. Analysis is used to identify both weak and strong points, thus providing content for subsequent practice sessions. When this kind of "games analysis" is used to guide planning for a team sport, the coach must be realistic in setting the goals for the practice sessions. The goals should be individual, realistic, and take long and short-term objectives into account.

Analysis of performance during competitions is one key to the development of top-level performance, particularly for team sports. Selected competitions could effectively be used as training opportunities. When coaches utilise competitions for training, they must set goals for how participation should affect players' skills and tactical development, as well as their physical and psychological capabilities. A coach may observe successful patterns and styles of play performed by other teams, and want to incorporate them somehow into his/her own team's performance (Broomhead, 1993). In order to do this, not only must the coach have a very clear idea about what he/she wants the team to learn, but also have the ability to communicate this information to the players. Progress and development can only happen if coaches share and communicate ideas and information (Broomhead, 1993).

Analysis of performance using observation, is also critical to coaching during the game, otherwise known as "bench coaching." It is a critical aspect of successful coaching at elite level. While thorough planning and preparation are essential to success, months or even years of effort may be wasted because of a single error by the coach at a crucial point in the game. Some coaches do have an almost uncanny ability to "read" a game and to make sound tactical decisions while they are under great pressure, while novice coaches often appear to be mere spectators who simply "watch" the action but "see" little (Launder & Piltz, 1999).

When observing game play, the differences between a skilled player and a less skilled player are apparent. The skilled player knows what to do and responds accordingly on court in order to fulfil the objectives of the game. The skilled player can read the game and seems to make accurate decisions under pressure in an unhurried way. The less skilful player does not know what to do when, cannot seem to cope with the speed of the game and has trouble making the appropriate decision about what needs to be done (Abernethy in Pyke, 1997). If skilful players are able to read the game and make good decisions under pressure, then surely their coaches must also possess these qualities. Practice sessions for top-level players should focus on refining these capabilities. Indeed, analysis of coaching behaviour has shown that the more successful coaches ask players a greater number of sport-specific questions during practice than the less successful coaches do (Claxton, 1988), which indicates that top-level coaches focus on the "thinking" aspects of the game.

The development of "Thinking Players"

A coach of top-level players must be concerned with teaching them how to read and respond to competition situations. Both the coach and the players must become "good" decision makers. A variety of factors will influence the speed and accuracy of decision-making, including the number of decisions that have to be made, the number of response options available, and the time available to make the decisions. Decision-making in the game is closely related to the concept of tactical awareness. It is very difficult to measure a player's decision-making ability on court. The ability to anticipate what is going to happen on a netball court, for example, can give a player more time to execute a response. One approach to measuring the accuracy of anticipation and decision-making is to present slides of typical netball situations to players and ask them how they would have responded

in the same situation on court. A coach could also use such slides to discuss many tactical situations with players or to outline the principles of play. Switching, double-marking, teaming, delaying tactics and zone defence are a few of the situations on court, which rely on the player's ability to anticipate the movement of the ball, the available space, the opposition and how the rest of their own team will respond (Latham & Reitano, 1997).

Videotapes of critical game situations can be used to stimulate the development of the anticipation skills of players. Players may need the coach's guidance to recognise the importance of what they see, as well as the appropriate decision and action to combine with that perception. The coach has to teach the players how to find and use the information. An example is where the attacking player moves into a space and receives the ball from a team-mate. She is successful because she gathers important information about the player with the ball from the stance of that player, her head position (including her eye focus), and the position of the ball, i.e. all of these clues about the direction of the pass (Latham & Reitano, 1997). In the same way the player in possession of the ball, needs to anticipate the pathway of her team-mate as she dodges and moves into the space available. The link between both players is central to the success of the pass: both have to anticipate and their timing and communication must be accurate. There are many other situations on court that call for tactical thinking. With information such as the direction of the pass, movement of a player, previous knowledge of a team and their style of play, awareness of three seconds and accurate timing, it is possible for a team to put together an effective counter-attack to neutralise the effectiveness of their opponents' tactics.

Because netball is a very fast team sport, anticipation, perception and decision-making are critical skills that top-level players have to master. Each player has to process what she sees, taking into account the ball, team members and opponents who are always on the move. The player has to recognise what she sees and then make a decision. Players have to access lot of information during a team attack, for example: who is likely to send the player a pass and where the player will be able to receive that pass. The player must also take into account how the thrower is being marked, what opportunities her own opponent will give her for receiving this pass, the timing of this move and the actions of other members of her team who may also be moving for that pass (Verroken, 1985).

Through small skill practices without any defence, the coach begins to teach players to read the game. But the long-term objective is that players will be able to solve a

problem on court without any direction from the coach during the match (Game sense: Developing thinking players, 1997). To achieve this aim, the coach has to provide the players with practice of solving problems and gradually increase the level of difficulty. The coach can use match statistics to learn the strengths and the weaknesses of a team, as well as any repeated patterns of play that characterise an opponent's play. This information can be used to sequence learning experiences.

The tactical approach

One instructional approach to improving game play involves the combining of tactical awareness and skill execution (Griffen, Mitchell & Oslin, c1997). In this approach, tactical awareness is identified as critical to game performance. Tactical awareness is the player's ability to identify the tactical problems that arise during a game and to select the appropriate response to solve the problem. According to Griffen, Mitchell & Oslin (c1997), this approach develops the link between skills and tactics, which in turn enables the players to learn about the game and improve their performance. Motor skills are still regarded as central to game performance, but decisions, concerning what to do during the game, are equally important. Players learn to recognise the need to perform a technique during the game, which makes the performance of that technique more meaningful (Thomas, 1997).

Some players do not know how to react in a critical situation. The increased understanding of the particular game achieved through teaching for tactical awareness, empowers players to solve problems during a game. Players of invasion games such as netball, spend most of the time making tactical decisions and moving to execute those decisions. According to Griffen, Mitchell & Oslin (c1997), the tactical problems in invasion games are typically divided into three categories: scoring, preventing scoring and restarting play.

- *Scoring* can be sub-divided into maintaining possession of the ball, attacking the goal and creating space while attacking and using space in attack effectively.
- *Preventing scoring* can be sub-divided into defending the space and defending the goal and winning the ball.
- *Restarting play* includes events such as throw-in and centre pass in netball.

Coaches encourage players to do critical thinking and problem solving by asking many questions during a practice game. Firstly, the coach may ask what the players must do in the situation and then, why certain skills or movements are required in the situation. As soon as players become aware of what they need to do and why, the coach may ask how the necessary skills and tactics should be performed. Improved game performance is proposed to be the outcome of increased tactical awareness.

The game sense approach

The game sense approach is sometimes regarded as a variation of the tactical approach. In this approach, both skill techniques and tactical thinking are taught together during game or mini-game situations. The coach determines when it is necessary to work with individuals or groups on certain aspects of the game. Turner and Martinek (1999) found that this approach helped players learning the motor skills required for game performance as well to make more accurate and successful decisions during a game. Players also had a better understanding of the rules and tactics of the game.

According to Hastie (1998) skills and tactics are linked, and as players become more skilful, they should have more options available on court during the game, providing that their "game sense" has also improved. Skill development may occur much faster than in the traditional "skill-drills" approach. In the games sense approach, players think about what they are doing and why they are doing it. The coach teaches skill technique during the game and only when the need for the skill arises. Through the game sense approach players learn to analyse their own actions and they gain more knowledge about the game and its rules (Charlesworth, 1994).

Within the game sense approach, training sessions start with a warm up, followed by a "game sense" game that focuses on how a team can accomplish a particular goal. Once they find a successful pattern of play, they analyse it to see whether there is a better way or alternative ways to accomplish the same goal. To increase the challenge the coach can make modifications to the number of passes and players, by changing the game rules, or by changing the time or the court (Den Duyn, 1996). Games can be used during the warm up session as well. During the traditional training session the coach dominated and was the only person that made the decisions. Nowadays the coach uses questions to guide the players to tactical thinking, for example, "what is the best way to defend this

situation?" The coach may design games, or modify and adapt games. But first, the coach has to identify the aim of the game. What are the game sense skills involved and what specifically does he/she want to teach the players? Within each game there are some questions that the coach can ask to help the players with their thinking and analysis (Den Duyn, 1997). An example of a game sense approach game can be described (Den Duyn, 1997:10) to coach the long pass in netball. The game sense skills involved, are risk, space, time and decision-making.

The game:

- Two equal teams
- One team attacks and the other defends
- 30 second time limit for each team before changing over
- The court is divided into three zones. One point is awarded for each successful pass within zone 1 to 2
- Five points are awarded for a successful pass from zone 1 to zone 3
- Five points are deducted if the long pass is intercepted and one point is deducted if a short pass is intercepted
- Each team tries to improve the total number of points scored in 30 seconds

The coach's questions to players:

Attackers:

- Is it better to lose one point passes or just a couple of five-point passes?
- When is the best time to go for the five-point pass?
- How can you help to "free up" a team-mate in zone three?

Defenders:

- How can you make it harder for the other team to achieve a five-point pass?
- How can you adjust your game if the other team is scoring lots of five-point passes?
- What is the best type of defence in this situation?

Modifications:

- Restrict number of players allowed in zone three

- Change the dimensions of the zones

Coaching and the Process of Evaluation

Evaluation can be regarded as a process where coaches gather and analyse every bit of information they can in preparation for the next event or competition. Evaluation goes far beyond recording the final score of the game, time, distance, placing, etc. In team sports the coach will look at information such as, the number of successful and unsuccessful passes, the number of turnovers, etc. This will help him/her to plan tactical games or games sense sessions to help the team improve their execution of skills, tactics and use of game strategies (Crouch, 1992). By analysing both training performance and match performance, for example, the critical sources of success and failure can be identified. Comprehensive evaluation can reveal the level of conditioning, the mastery of appropriate techniques, the tactical awareness of the players and decision-making of players on court.

Marginson (1979) states that coaches do not spend enough time evaluating their players in match situations. Because players have to apply skills during game situations, the ability of the coach to evaluate both individual and team performance during actual competitions becomes crucial to team improvement. When the coach finds some weaknesses, he/she can immediately plan how to correct the individual or team's performance. This may mean providing feedback during the match, or it may require the re-organisation of training sessions in order to address weak areas. In either case, the coach must develop the skills needed to evaluate situations on court if players are to progress from beginner to more advanced levels of play.

Observation

Observation is an essential skill for coaches to analyse match play (Thomas, 1982). Observation can be effective in determining the actual skills used by players as well as to note the variety of directions used in passing the ball, the tactical emphasis of one's opponents, watching only one player and analysing one particular movement or skill. The skill of observation is certainly one of the qualities of an experienced coach. Experienced coaches have specific objectives when they observe. Some make observation checklists before each game or practice session. When a coach observes an individual player, the focus could be on a skill, for example, throwing technique, and whether the particular

player shows variety in play as well as which side they prefer. The coach could also observe tactics, for example, the centre pass patterns used and the tactical responses of defending players. By looking at one section of play at a time, the coach will find that careful observation becomes a habit. Once a coach can see what is happening, he/she can explain the problem to the player and/or design appropriate practice activities to help the player overcome the problem. Good observation forms the basis for good coaching (Methven, 1985).

Most coaches obtain a lot of their information by observing players, but this is not the only method to be used for the evaluation of performance. Research has shown that international-level coaches could only recollect 42% of the key factors that determined successful soccer performance during one match (Hughes & Franks, 1997). Experienced coaches made a lot more false positives by observing performance, than inexperienced coaches did. Coaches have to observe a live event and collect details of performance during the match. After the match it is extremely difficult for coaches to recall these details again. In invasion games like netball, coaches are faced with a large number of events during the game. Different players in varying playing positions perform the events at different times during the game, which makes it impossible for coaches to remember all the details. Computer technology has made the gathering and management of information much easier by providing the coach with a rich source of information on which to base performance evaluations.

Match analysis

According to Launder & Piltz (1999), the collection of 'hard data" on match performance at a basic or advanced level can be valuable in that it gives coaches a clear picture on the performance of future opponents or of one's own team. With sophisticated computer programs coaches can get access to "real time data" as well. Match analysis can provide some insight information that would increase the chances of success for a team. Match analysis has revealed that action in one specific zone - sometimes called "the hole" - made the difference between success and failure in a game. But having access to more information than can be gleaned from direct observation, is useless unless the coach knows how to interpret and respond to the available information.

The process of match analysis, the ability to really "see" what is happening at every instant of the game, underpins bench coaching. The coach must note, interpret and react to continuous sequences of action. To "see" in this sense implies that coaches have the capacity both to direct their observation to what is really important and to know what to look for. Effective match analysis is based on a thorough understanding of the fundamental nature, strategy and tactics of a game. For invasion games such as netball, these are encapsulated in the "principles of effective play". These principles provide the verbal and conceptual " template" necessary for intelligent observation and thus help to simplify the process of analysis. They also provide a common tactical language for both coach and players, which makes communication easier and helps players to more readily understand their role in the total team effort (Launder & Piltz, 1999).

To become skilful at match analysis, a coach must watch many matches, particularly at a higher level than the one he/she is coaching. According to Launder & Piltz (1999) the following practical learning experiences will help coaches to develop their match analysis skills:

1. Interactive "simulation" session (focused observation of game play)

   A coach observes an individual player. After the practice game, the coach provides the player with specific feedback. Once the coach is successful in dealing with one player, the task can be made progressively more complex by adding more players to the observation list.

2. An apprenticeship experience (a mentor programme)

   The coach observes a game that his/her mentor is coaching. The coach focuses on something specific in each half of the game. The coach has to identify the dominant players in each of the teams, and describe the pattern of attack used by both teams as well as the pattern of defence. His/her evaluation is then checked for validity by the mentor coach after the game.

3. Self-directed learning package

   The coach observes a game from a sport, similar in type to his/her own, e.g. a netball coach observes another invasion game. After observing the match, he/she answers the following questions:

- Is the template of the "principles of play" a valuable tool for observation?
- Was the game tactically interesting (similar principles of play)?
- Was it possible to transfer knowledge of his/her own sport to the sport being observed? (p.27)

The effectiveness of match analysis as a tool to support evaluation is centred on the coach's comprehensive knowledge of the game. In order to analyse a game or a player, the coach has to compare the player's technique with a concept called an "optimal technique" in the situation observed. The coach has to determine the cause of the error and then determine how the error should be accommodated. The coach has to give simple and precise corrective feedback, making sure that the feedback is well understood by the team or the players (Robert & Daniel, c1988).

A System of Match Analysis

According to Hughes, Franks and Nagelkerke (1989), the technical analysis of sport performance falls into two categories, cinematographic analysis and notational analysis. Frame by frame analysis of film (cinematography) provides accurate and detailed results. These techniques have been used to study skilled actions and the detailed biomechanics of movements of individual players, rather than the overall patterns of movement of a group or team.

Notational analysis enables quick and immediate analysis of a movement situation, such as a time period in a game. To gain the most relevant information about performance using notational analysis, the coach should guide how the system will be designed and what information is gathered. The product of notational analysis usually includes a flowchart of the game that indicates the frequency of certain actions in the game, how these actions relate to each other, and the outcomes of the actions. A typical analysis indicates, for example, the area where the team lost or gained possession, the player that gained or lost the possession and how it happened? The coach must identify and prioritise any key factors of performance that he/she wants traced during the match. According to Hughes & Franks (1997:29), the most common organising elements of any match analysis system are:

Player

Position

Action

Time

The original systems of notational analysis required that all the data be recorded by hand. In general, hand notation systems were accurate but it took up too much time to evaluate the data to produce meaningful information for the coach. Computer programmes are now available to support notational analysis in sport, which can speed up the process considerably. Hughes (1997:27) has identified four major support functions that notational analysis can provide to coaches:

The analysis of movement

A description of tactical performance

A description of technical performance

A compilation of games statistics

The advent of on-line computer facilities overcame the problems that hand-recorded data posed. The game could be digitally represented because data collection was completed directly on a computer. The data could then be categorised according to specific queries, pertaining to the game, made by the coach. The information the coach can get from this type of computerised system can be used for several purposes (Hughes, 1997:27):

To provide immediate feedback to players about their performance

To develop a database about one's own team as well as opponents

To identify areas requiring improvement (content for practice sessions)

An overall evaluation of team performance

To assist in the identification of key performance areas when searching through a videotape record of the game

Using computers does introduce its own set of problems, for example, problems with the hardware and software may occur or the wrong data can be entered. If possible, it is recommended that one person should enter the data by hand on a sheet while another

person enters the data into the computer. In this way the hand-generated sheets are will be available, should any technological problems occur.

The use of technical experts to perform notational analysis is increasingly common in top-level sport and among expert coaches. The technical expert determines the level of analysis needed according to the needs of the coach and the team in a particular situation. A team could need information in each category. For example, if a shot was taken, the analysis should not only report whether the shot was on or off target, but also if the shot was off target, more information could be gathered, e.g. where the shot was taken from. Information on set pieces should be identified as a success or failure. Definitions of success and failure should continually be upgraded to the level of performance, as well as the realistic expectations of the coach. According to Hughes (1997:33) the following is an example of basic game analysis in soccer:

1. Possession information

   How much possession did the team have during the game?

   Where on court was possession won or lost: defending third, mid-field third or in the attacking third?

2. Passing information

   The type of pass, is it a square-, back-, forward- or a consecutive pass?

3. Shooting information

   When the team got shooting opportunities, was the shot on or off target, was the shot blocked and what was the shooting angle?

4. Set piece information

   Set pieces can be classified under the headings corner kick, free kick or throw-in and the success or failure of each can be recorded

Computerised notational analysis has already been applied to a variety of sports, like soccer, rugby, squash, hockey, water polo, fencing, wrestling, ice hockey, basketball, sailing and volleyball. The major benefit of notational analysis, for many coaches, is that it enables them to identify the patterns of play of both their own team and their opponents. The benefit of the laptop computer with their lightweight printers is that the sport scientist

can now support a coach by collecting data at an event, then analysing it instantaneously and printing out the results immediately.

Computerised notation analysis applied to sport

Some form of match analysis has been applied to netball since 1978. Coaches generally used video footage to analyse individual players' biomechanics as well as patterns of team play. A hand notational system was developed to track the ball from the centre pass to the goal, for example. Movement patterns during practice and game play were also analysed. According to Barham (1980:23), this system was specifically designed for use at the courtside. The system recorded the following actions of each player:

- Technical infringements
- Personal infringements
- Shooting records
- Throw-up results
- Passing and catching errors
- Rebounds and interceptions won

The system gave players a perspective on their own performance and was used to motivate the players to improve their skill. Each action recorded, had a special symbol. The recorder had to be able to make decisions quickly and accurately and netball experience was essential.

Football coaches spend hours viewing films to help them study the strategies, strengths and weaknesses of opponents. The attacking plays performed in soccer by successful teams can form a pattern. The possibilities of such computer systems are endless. The information that coaches receive after every match enables them to plan strategies and tactics accurately for the next practice session, as well as for the next match. When a few hours are available for processing match analysis data, the coach can be provided with still more information to support performance improvement. For example:

- Diagrams of every play displaying the path of every player, both offensive and defensive.

- The distance covered by every player and on every play.
- The recorded time of each movement and the recorded time spent by each player with the ball.
- A comparison of several executions of the same play.

The mini-system was a major development in computerised notation, specifically for soccer. A keyboard on a mini-computer represented the layout of the soccer field. The path of the ball, called "off-ball" incidents, could be followed through tallies of the various features of play. A video was time-locked into the system and the coach could replay the video to see different sections of the game along with the computer analysis. Church and Hughes have developed an alternative type of keyboard, called a concept keyboard, for the analysis of soccer matches. The board consists of a touch sensitive pad that can be programmed to accept input to the computer. The system can represent the patterns of play very accurately and quickly with respect to match outcome. To do match analysis accurately and successfully, data is collected on match parameters, for example attacks, scoring opportunities, set plays, free kicks and corners. After analysis of six matches, played during a season, using these computerised notation analysis systems, the following conclusions were made:

1. The losing team played a greater number of passes than the winning team;
2. Possession was lost through error more often when losing;
3. The losing team took a greater number of shots, than the winning team (Hughes & Franks, 1997:52).

Analysis of the 1986 Soccer World Cup finals revealed that successful teams played more significant touches of the ball per possession than unsuccessful teams. There were also significant differences in the patterns of play between successful and unsuccessful teams, especially on attack. The successful team used the centre of the pitch significantly more than the unsuccessful teams. After analysing a number of the games, expert coaches identified the "key factors" that could create scoring opportunities or prevent scoring opportunities. This type of analysis is also being used in hockey. Dalfour presented an analysis using computer-assisted video feedback and statistics that can produce a detailed evaluation of each player as well as the team performance in three different categories: physical, technical and tactical performance (Hughes & Franks, 1997).

An extension of computerised sport analysis is the development of interactive video technology on computers. A games analyst can selectively retrieve video images of any specific events such as goals and set plays. The analyst can choose from a menu of events to view any or all of the events within one specific category. The computer-controlled video interactive system presents the coach with the possibility of immediate analysis combined with the visual presentation of the action(s).

Despite the attractive features of computerised notational systems of games analysis, it remains the coach's responsibility to observe and analyse game play during a match. With extended coaching staff and technical assistants all contributing to the process of games analysis, there can be so many actions, by different individuals, over long periods of time, which can present problems in terms of maintaining the sensitivity, objectivity and reliability of observations (Handford & Smith, 1997). Considering the large amounts of data involved with recording and analysing the strategic and technical performance, however, a computer-based analysis system is an important source of support for coaches.

The attacking play of different teams in soccer has been analysed. The most difficult challenge was to spot the location of each player, but with the use of computer analysis the challenge was met. The result of the analysis revealed that when a team on attack creates time and space, is in possession of the ball and keeps this possession, a goal would be scored (Grehaigne, Bouthier & David, 1997). Another system was developed to record the movements and performance of players during a game. The computer programme to support this system can be used with or without video film analysis through a simple notation system.

Games analysis of ball games has provided useful information, but the clarity in the representation of results is still lacking (Kawai, 1997). During a study on soccer, Kawai (1997) tried to create a computerised notational analysis system that could accurately reproduce plays. Accurate feedback about match play is very important to the coach and players so that they can watch or discuss tactics after the game, in preparation for the following game. The computerised notational system used for this soccer study consisted of a computer, a digitiser and a programme to process input. The main menu on the programme consisted of "data collection, data analysis and player registration". "Data collection and data analysis" were supported with assistance menus. The collection of data was performed with a stylus pen on an input sheet on the digitiser and a videotaped replay

(VTR) of a match was reviewed. The sheet consisted of a small diagram of a soccer pitch, input frames of uniform numbers of players and an actual playing facility. Every ball movement was tracked by entering the data in the order of who (player), where (a place on the field) and what (an action, for example a miss-pass). The start and end time of plays were recorded automatically to estimate the duration of one play. After analysing two matches, accurate reproductions of actual play with the ball could be given.

Kawai (1997) was able to confirm the tactical role and achievements of a player, from passing during a match, to the reproduction of passing. Two different kinds of indications were used to analyse the pass. One was an indication of the locus of passing by one player on the field where the team-mate that received the pass was shown. The other one was an indication of the starting point of a pass. Statistics were also used as an indicator, for example, a calculation was made of the number of passes, miss-passes, the total number of passes, etc. The game analysis also presented information on the passing sequence as well as the passing frequency between players. The passing frequency between players can be crucial information because it makes the identification of the key players in a team possible. The total number of mistakes made during a game is also a critical factor and can have an influence on the result of a match. A player profile can be very useful for the coach to evaluate the individual player, which is why games analysis also produces a summary of each player's personal results.

Hong & Tong (2000) used notational analysis to profile the playing patterns of the world's top badminton players in single competition games. A total of ten matches were videotaped and "notated" frame-by-frame to analyse the players' strokes. Each stroke was classified into a category. The videotapes were "notated" throughout the tournament and for each player, each shot was recorded with symbols to describe the position of the stroke, kind of stroke, location that the shuttle reached and the effectiveness of every shot. After the matches, the basic statistics of the games just played, were available, as well as the percentage distribution of shots for each of the six court areas. Through analysis of this information it was discovered that the left rear court contained the highest rate of ineffective shots, with the left forecourt receiving the highest rate of effective shots. The highest rate of "forced failure" shots was found on the mid-court, with the highest rate of the "unforced failure" shots found in the rear court (Hong & Tong, 2000). The winners at this high level of play made fewer errors and their key strategies involved creating pressure and pursuing the attack game. This method of notation has been used in a variety of sports

to analyse the activity and playing pattern, sports such as, rugby, soccer, netball, squash, cricket and tennis.

A notation system for netball

Hughes, Franks and Nagelkerke (1989) used new techniques developed in computerised notational analysis and then created a system that would enable immediate analysis of movement by means of a video of the event as well as accurate data on position, velocity and acceleration. They had noticed that many teams go through good spells and then loose momentum very quickly. With the support of notational analysis, the coach should be better able to identify the reasons for good performance as well as those actions that cause a drop in performance. If notational analysis could be used quickly and easily, it could help resolve problems on the court and help players make changes before they lose their confidence in their ability to be successful. Once information about the critical indicators of success in netball is identified, this information could be used to improve the training of coaches, which could help improve the quality of netball in general (Nicholson, 1997).

The development of a notation system for netball followed logical procedures. Netball consists of seven players and each player has a restricted area in which to play and a specific role to fulfil. Team members must try to score as many goals as possible while limiting the scoring of the opponents. The objective of the game is to maintain possession of the ball and to score goals. In an attempt to assist with systematic notation, the court was divided into five functional areas for match analysis (Hughes,1997:133):

The goal circle

The goal third

The centre third

The goal third

The goal circle

Each recording sequence started when a centre pass was made (represented by the symbol "C"). The players and positions are then noted continuously. A sequence is completed when a goal is scored. Several important factors can be tracked easily. The number of possessions by each team can be counted. The number of passing errors by a

team or the frequency of passing errors by a particular player can also be counted. It is also necessary to count or evaluate the number of touches of the ball by the player, to calculate the percentage of passing errors. This level of analysis makes it possible for the coach to see whether the team used all seven players. A passing error was defined as when ball possession is lost, the ball possession changes direction or when the ball goes out of court. It is also possible to calculate the average number of passes in a sequence from the centre pass. The most common sequence in netball is a three-pass attack from the centre pass to the scored goal. The greater the number of passes, the greater the opportunity to lose possession of the ball. The percentage success rate of the GS and GA can be calculated easily (Hughes, 1997).

To make the entering of data easier, other sports have tried using a sensitive touch bit-pad as an alternative keyboard. The analyst just has to touch the sensitive area of the keyboard to track a player within seconds. The system has been used to accurately measure the movements of squash players during competition. There is no reason why this system cannot be used for netball. The system can provide immediate, detailed analysis of the motion in competition, which is not possible with film analysis. Improved quality feedback could be given to the coach and a broader field of research to the sport scientist.

Games analysis was also used to determine the characteristics of activity patterns of each playing position in netball (Otago, 1983). Games were analysed, using videotape recordings. The activity of each player was classified according to categories, such as sprint and shuffle. The information was obtained by focusing on one player throughout the match. Each player's movement was recorded as well as the time spent on each activity. The different work rates and different skills used by players at the different positions were documented. Centres were active almost throughout the game, jogging slowly when sprinting is not required. Wing Attacks were sprinting most of the time, while defensive players spent the highest percentage of time shuffling. The circle players were jumping more often and Wing Defence players were guarding for the biggest part of the game, with the Centres passing the ball the most. This information should contribute to more position-specific training programmes.

The importance of a team having accurate shooters is highlighted when a team plays extremely well with good skills and good tactical plans, but their shooters do not score. According to Elliott & Smith (1983), match statistics related to shooting accuracy

under game conditions are crucial for coaches. What shooting percentage can a coach expect from her shooters during a game? During game play, they recorded the following: the number of successful goals, attempted goals as well as successful and unsuccessful standing shots for each player in a shooting position. The goal circles represented on each analysis form were divided into three sections. They also recorded the number of successful and unsuccessful shots (medium and long shots) for each player. The results of the study indicated that the team had to play the ball as close to the goal post as possible. The reason for this is that shooters are most accurate when close to the goal post. The implication for coaching is that each shooter should know her own goal shooting percentages over the different ranges of the goal circle. Practices should be designed to overcome the shooter's weak areas of play.

Match analysis is recommended as a source of information about performance that can be used in the coaching process (Palmer, Borrie, Burwitz, Whitby & Broomhead, 1997). A system was developed for netball and a report was made, based on data from an international match between South Africa and England. The programme was written in Visual Basic 2 Professional Edition for Microsoft Windows 3.1, which is a Graphical User Interface. An IBM compatible laptop computer was used in conjunction with a concept keyboard. An overlay delineated the court into an inner and outer circle, each with four sub-cells (Palmer, Borrie, Burwitz, Whitby & Broomhead, 1997). The system provided basic information about both teams, specifically, centre pass play, feeding into the goal circles and shooting. The information was given to the England coach after each match and she could then use the information to produce plans, which were implemented during the practice sessions before the next match.

According to Croucher (1997), a computer programme NETSTAT was used to analyse several international games. The Australian team used it during the 1990 Commonwealth Games in New Zealand where they won the gold medal. NETSTAT consists of several parts or phases, a sheet for match information and a sheet for match data. The data can be entered into the computer program for match reports (Croucher, 1997). The purpose of NETSTAT was to provide a scientific analysis of netball. The benefits of the programme were identified as (Croucher, 1997:10):

1. Records of individual players or a selected netball competition can be recalled.

2. The strengths and weaknesses of players can be identified.
3. Reasons for success and failure can easily be identified.
4. Methods and tactics for successful performances can be developed.
5. Decisions can be made based on the information.

The information recorded, using this programme included general match information, team list, minor infringement, major penalties, results of toss-ups, lost balls, passing, the number of rebounds, deflections and interceptions made, full goal shooting details and possession gained from open play. One important aspect was that coaches could clearly see the number of times that the team was able to convert "unexpected possession" during play into a goal. This possession is normally obtained during the match as a result of the opponent's team mistakes, bad passes, or bad catches. This can be a bonus for any team.

As part of the research completed for this thesis, a notational analysis system was used at a test match between South Africa and England. When South Africa won the test match in London by 55 goals to 36, the results showed that South Africa's shooting percentage was excellent compared to that of England. The analysis also showed that South Africa's Goal Shooter dominated the attack in the goal circle and took over 90% of the shots. There was a significant difference between the two teams' centre pass recipients. South Africa predominantly used their Goal Defence and Wing Defence on throw one of the centre passes. England used the Wing Attack dominantly on throw one. This data was in contrast with previous research on international teams. It is important for the analyst to tell the coach who is consistently receiving the centre pass, and also where the player receives the centre pass. The second pass of the centre pass went to the Wing Attack or Goal Attack in the South African team. The South African defensive players let the first ball go to the Wing Attack and put more pressure on the second pass of the centre pass. The second throw of England went to the Centre and Wing Defence most of the time. England played 15% of their second throw of the centre passes to the Goal Shooter, which is a tactic of successful teams. In contrast, South Africa did not throw any such pass to the Goal Shooter. The Goal Attack of South Africa did most of the feeding into the goal circle and was very successful. The Wing Attack of England did most of the feeding into their goal circle and had a lower success rate than the South African team. The reason for this can be traced back to the centre pass recipients, who received the first or the second throw.

The feedback on the use of this notational system from the South African coach was that the system could not give enough detailed information. However, the coach felt very positive about the system and felt that it was useful to communicate important details to players.

The Use of Match Analysis

The extraordinary demands on the time and energy of coaches have created a pragmatic attitude toward innovations in coaching technology: the technology must produce a useful product or have a "real-world" positive impact on coaching and sport performance. Technology is not regarded as a luxury in modern sport, instead, any proposed "technology advance" must demonstrate that it has the potential to improve coaching and sport in practical settings. Match analysis certainly has the potential to have an impact on a variety of different features of coaching performance by providing coaches and players with valuable information that can be used to improve performance. A schematic diagram is presented in order to give an insight to the reader to understand the coaching process by using computer-aided analysis as well as feedback technology.

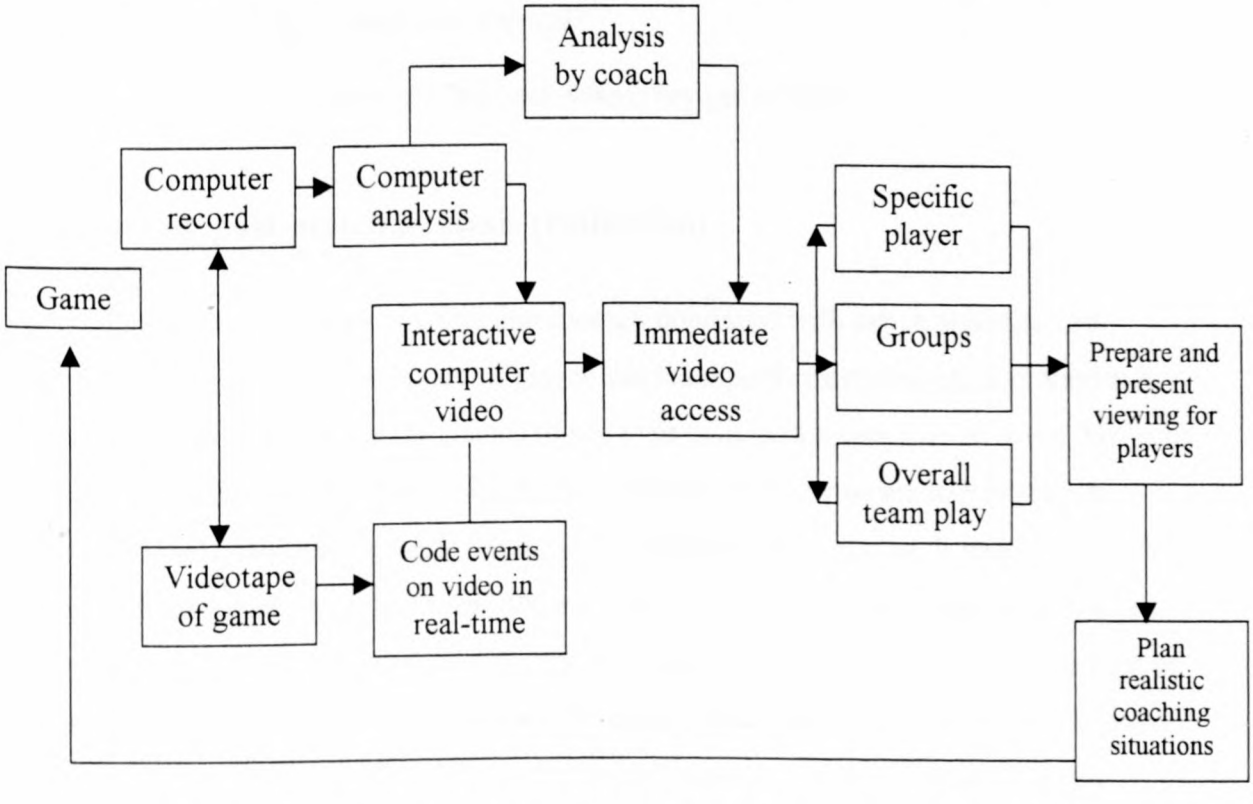


Figure 2.1 Coaching process (Hughes & Franks, 1997:16)

Supporting pre – game match analysis (scouting)

Pre-game match analysis involves the observation and analysis of future opponents. The observation can be done by video or by observing a match of the opponents. It can provide the coach and players with knowledge about the opponents' tactics, strengths and weaknesses. It gives the coach and players a good idea of how to predict and prepare for specific movements and tactical situations of individual opponents. Because specific patterns of play may differ from game to game, it is probably not worthwhile gathering statistics of every single game played by the opponents. A scout must analyse key matches in order to identify the crucial elements of an opponent's style of play. For example (Launder & Piltz, 1999:27)

- How does the team combine in attack?
- Who are their key playmakers?
- How fast do they counterattack?
- How well do they recover in defence?
- Are they tough and physical?
- Do they keep coming back when they get behind?

Supporting post-match analysis (reflection)

Post-match analysis of game film footage combined with match statistics can ensure that a very objective picture of player and team performance emerges (Launder & Piltz, 1999). It gives players the chance to see their own performance and it gives the coach the opportunity to constructively plan future strategies for improvement. Post-match analysis is worthwhile at any level of play – from elite down to novice. It gives the coach a specific focus for practices and helps players understand the reasons behind the objectives selected for practice. A number of different records may be kept, depending on the kind of sport. Records may be kept of the number of times a player gives the ball away in a low or high pressure situation, the number of misdirected passes, the failure of the player to quickly take up an appropriate defensive situation, the number of involuntary rest pauses a player has to take during a game and the pattern of effort by a player at different stages of the game. According to Smith, Nettleton and Briggs (1982) the purpose of post-game

analysis can be to provide the coach with information about the player's performance or the team's performance. This information could provide a link between the game and the next practice session.

During the research completed for this thesis, game performance was analysed in three general categories: fitness, game skill and decision-making. Through analysis of errors made by high-level performers, it was discovered that the reason for the errors could be attributed to poor/incorrect decision-making. The players possessed a high level of skills and tactics and yet repeatedly selected the inappropriate tactic and/or skill for the specific situation. Post-game match analysis revealed that the link between performance and decision-making needed a lot of work. The nature of team games is such that the situations on court change continuously. Every change on court requires a whole series of decisions from players. One incorrect decision by a defender may lead to a goal being scored. An incorrect decision by an attacker might mean a goal being missed. During an hour-long game, a specific player could be in possession of the ball for only three minutes. When a player does have the ball, the decision made about what to do with that ball is very important. Because netball is a team sport, the decisions made by the other players on court, those not in possession of the ball, are also important. To improve the quality of players' decision-making, the coach needs to teach them the principles of play. Because match analysis is based on the principles of play, a post-game match analysis acts to reinforce players' knowledge of the game and encourages them to become more thoughtful about their sport.

Providing feedback

Feedback is information that the players receive as a consequence of their performance (Robert & Daniel, 1988). It is one of the most important variables in the process of learning and it can also help players maintaining high levels of performance. Providing useful feedback to players is possibly the most critical quality of coaching (Daly & Parkin, 1997). Augmented feedback is information that players would not ordinarily receive from their performance. This information is provided by an external source, such as the coach, team-mate and/or information on the videotape system. This feedback can be used differently. In top-level sport, it is used primarily as information to correct errors and as information to reinforce correct performance. The use of modern match analysis systems makes it possible to gain accurate, reliable information and thus allows the coach to make

an informed decision about the most appropriate form of feedback to give to players (Franks, 1997). The feedback can be given verbally or non-verbally by demonstration, statically by means of video information.

Feedback as information to correct errors

It is crucial that coaches have sufficient knowledge to accurately diagnose the source of errors in players' performances. The information that a coach provides to a player as performance feedback has to pertain specifically to the movement or technique that the player has to improve (Crouch, 1992). According to Hughes (1997), the goal is to concentrate on specific "key factors" that, when mastered, will lead to a correct performance. Because match analysis provides an analysis of play according to key factors, it helps the coach and player specifically to identify problem areas and the frequency with which the problem occurs. When videotape analysis is provided, the player can actually see when and where she is making the errors, which should make it easier to work on correction.

Feedback as reinforcement of correct performance

Even when players reach an advanced level, they still need feedback to reinforce what they are doing correctly. Once again, because match analysis provides an analysis of play according to key factors, it helps the coach and player specifically to identify those areas of game performance that are proving to be successful. These are the areas that the player and the team would want to expand and emphasise. When videotape analysis is provided, the player can actually look at what her team-mates and her opponents are doing, and recognise why she is successful. This provides her with a reason to maintain that style of play.

The use of video feedback

One of the benefits of using a video feedback system is that players can view their whole performance. The coach can also provide the players with visual examples of what to do, and what not to do, in actual game situations. This can be more effective than verbal instructions or simulated game situations. Video feedback also encourages players to think

about playing principles and to analyse their own performance. The players may need someone at the feedback sessions to draw their attention to the key elements of performance. Two problems must be resolved if a coach wants to make effective use of video feedback. The first problem is that either the coach or a qualified assistant must be able to identify the critical elements of successful and unsuccessful performance on the videotape replay. The second problem is time – the video system adopted, has to provide feedback quickly, and that feedback should highlight only the critical elements of game play.

The usability of any film or video-based match analysis system is based on a good cameraperson who is able to capture what a coach wants. Before players view any tapes, coaches should preview the tape and make notes on the successful and the unsuccessful movements. Generally, the film is shown to the team as a group, but a coach may want to emphasise certain sections for a specific individual or group. Immediate feedback can help the player to eliminate errors and to correct the errors immediately. But it must be remembered that the video or film is a one-way communication channel. Each player should also have a problem-solving discussion with the coach. Players need to know what the coach sees in their performances. Machines with a slow motion action can be ideal. Short viewing periods plus the coach's analysis should be followed by an attempt to correct as well as improve upon performance. Any feedback from the coach to the player must be phrased positively, rather than in a negative manner. Informing players only about their mistakes is not optimal. The coach may have to tell some players why they were unsuccessful and how they can correct or avoid making the same mistakes in the future. More advanced players should be encouraged to analyse for themselves. The following performance analysis tips are suggested for coaches and players when viewing filmed or taped replays (Taylor, 1979:59):

1. Each viewing session should isolate small clips, such as a specific movement or game play.
2. The player should be encouraged to give an active response, becoming involved in the learning process.
3. The player needs immediate feedback regarding the correctness of action and technique.

4. Players should be allowed to work at their own pace (viewing and re-viewing video replays).
5. Players should have the ability to identify and emulate what they have observed.

Learning tactics

According to Crouch (1992), a feature of good team skill is the ability to apply the correct game plan at the appropriate time within the parameters of an overall game strategy. Strategy can be defined as the plan for the management of the skill and tactical aspects over a season. The coach can analyse the information provided by match analysis to produce a series of learning experiences with the full range of tactics that the team will be using over the course of the season. Practice sessions can be used to help players understand how to combine their skills with the tactics. Simulated competitions can be set up and match analysis can be used to look at the progress of the team in execution of both skills and tactics. Through this process the coach can make the challenges of decision-making during the match easier for players. According to Robert & Daniel (c1988), practice alone is not sufficient enough to learn a skill or a movement correctly. There must be a specific focus for the practice. Match analysis can provide the critical information needed to make practice sessions meaningful.

Planning for a specific event

The preparation of the team for a specific match or event is a vital part of a coach's strategy. The coach can analyse the information provided by match analysis to produce the suitable tactical plan for a particular match. Planning for a specific event can be divided into a pre-event, in-event and post-event phase. During the pre-event phase, the coach has to gain as much information as possible relating to the opponents. Information can include aspects such as the composition of the opposing team and the strengths and weaknesses of the opposition in terms of attack and defence tactics. Pre-event information can help the coach and the players to (Crouch, 1992:130):

- take advantage of the opposition's weaknesses.
- neutralise their strong points.

- compensate for any weaknesses the team might have.
- optimise your team's own strengths.

Netball coaches are not allowed to coach actively during matches, but there are breaks and halftime is the ideal opportunity to communicate with the team. It is very important that the coach provides the team with the most important and efficient information during these breaks. The coach has to concentrate on providing feedback concerning the performance and instructions with regard to tactics, as well as encouragement. The coach can give feedback as well as criticism, but has to be careful and only give feedback relevant to the situation. Feedback must be obtained and used as a measure of whether or not the coach has achieved her objectives (Crouch, 1992).

Feedback should be provided to players immediately after the game. Without feedback, no learning and improvement will take place. Feedback can be used as a measurement to compare what the coach had intended her team to achieve with what was actually achieved. It is very difficult to analyse play objectively during a match because of the speed of netball. It is possible, however, for the coach or an assistant to keep track of events such as goals attempted and gained, number of penalties given away and number of foot faults committed while the game is in progress. This is a simple analysis that can be done by filling in a match analysis sheet on the bench. Even without video support, a coach can gain valuable information by looking for trends in a series of these simple match analysis worksheets.

Conclusion

Coaching is a multidimensional profession that requires knowledge and skill in a number of areas, including exercise physiology, motor learning, motivational techniques, public relations, and budget administration. Expertise in coaching places increased emphasis on the scientific aspects of the game, including more demands on the coach's understanding of fitness, mental skills, motor skills, and the tactics/strategies of game play. Coaches now make use of the technology of match analysis for information about critical indicators of success and failure in individual players as well as team performance. Coaches have identified some requirements for a "user-friendly" system of analysis (Barham, 1980:23):

1. The system has to be simple, clear and easy to use.
2. It must record both objective and subjective data showing positive as well as negative occurrences during play.
3. Some information must be available immediately at the court, to use during intervals of play.
4. It must fulfil the needs of individual players and particular teams.

Within this research, notational analysis will be explored as a source of information for netball coaches. Firstly, it will be used in real-time analysis to provide immediate feedback during a game, which can be very helpful to the coach when planning tactics for the next quarter or half. Secondly, because it is a video-based notation system, it will also be used to break down specific periods of play, a movement, motion or position of a specific player on court. This can be used to provide post-game feedback to both coaches and players. Through this method a coach can access information about players' strengths and weaknesses as well as information about the opponents. Thirdly, it will be used to identify the critical indicators of success (and failure) in patterns of play in netball. If the system is effective in this regard, netball coaches can use it in general to analyse their own teams' play, as well as provide new insights into which tactics should be taught to players during practice sessions.

Chapter Three

Methodology

The research method and procedures used in this study are described in the following sections.

Research Design

The qualitative research methods associated with a case study were selected to guide this study. According to Borg and Gall (1989), a case study requires a researcher to make a detailed assessment of an individual, a group or an event. A case study may include a variety of data collection methods. In a case study the collection of extensive information is necessary in order to produce an understanding of the person(s) or event(s) being studied. The validity of a case study is based on the premise that the knowledge gained from focussing on the specific individual, groups or event targeted for study, can be applied to other similar or "typical" cases.

For the purpose of this research, a detailed study was made of three international netball games. Together, the games were regarded as a "case" of international level netball competition. Two approaches to data gathering were taken. Firstly, four top-level netball coaches, who were asked to analyse the games in order to identify the "critical indicators" of performance success or failure, provided expert analysis. Secondly, computer-based games analysis was used to analyse game play in each of the games. The insights from the coaches were then compared with the information generated by computer-based analysis in order to determine a level of "agreement," as well as to identify what, if any, additional information is provided by computer-based analysis. By putting these two views together, an in-depth analysis of "the case" was provided.

The case study method has the potential to generate subjective data that can develop into theory and or empirically testable hypotheses (Borg & Gall, 1989). The information used for this case study was "direct response" data. Direct response data includes insights and information gathered during structured interviews conducted by the researcher. The computer-based games analysis system produces data as the outcome of

the application of a games analysis programme by a qualified technician. Because a person guides this analysis system, it is regarded as a systematic form of qualitative data gathering. Through these two means of generating data, the researcher obtained specific information, perceptions and opinions about the critical indicators of success/failure in international level netball, as well as the value of computer-based technology as a tool to support games analysis.

Procedures

The following procedures were followed in implementing the case study approach.

Selection of matches

Three videotape recordings of international games were chosen randomly by the researcher from recordings of games played by the top five netball countries in the world. The researcher attended the specific matches as match analyst for the South African team. According to the 1999 Netball World Championships, the countries were ranked in the following order:

1. Australia
2. New Zealand
3. England
4. Jamaica
5. South Africa

The videotapes used, were the property of the Sports Technology Centre of the CSIR. Recordings from the following three matches were used in this study:

- Australia vs. England, October 1999, during the Netball World Championships in New Zealand.
- South Africa vs. New Zealand, October 1999, during the Netball World Championships in New Zealand.

- South Africa vs. Australia, June 1999, during the Fisher & Paykel Netball Test Series in Australia.

The New Zealand Broadcasting Commission recorded the World Championships games, while the Australian Broadcasting Commission recorded the Australia vs. South Africa game. All of the games were played indoors and consisted of four 15-minute quarters.

Expert analysis

In order to provide the initial analysis of the games, four expert netball coaches (Appendix B) were invited to view videotape recordings of the three international netball matches. Two of the coaches were provincial team coaches, and two of them were national team coaches. Three of the two games were chosen randomly and shown to the two provincial coaches. These two coaches worked together to analyse the two videos. The remaining game was analysed by each of the national coaches, who completed their games analysis individually. Each national coach chose a second game and individual games analysis was produced on those games as well. This was to ensure that every game had been analysed by at least two coaches.

The purpose of the expert analysis of the matches was to determine critical situations on court. The researcher was present at each session to stop the tape whenever requested to do so by a coach. Each coach could stop the video whenever they wanted to:

- identify a critical situation on court
- identify key factors that could prevent scoring opportunities

The videotape playback machine had a pause facility, which was used to stop and restart the tape, to allow maximum continuity in the analysis. Each coach followed the same procedure during the first and the second videotape. At the beginning of the session the coach received a form on which to fill in the necessary information. The coach had to write down the information on paper. More specifically, the coach had to provide an explanation for each important situation:

1. What happened on the court

2. The general error

3. The movement that lead to the situation

   The coaches were then asked to make their own recommendation of how to solve the problem/source of error in the specific situation

Each coach was asked to give her own opinion. The provincial coaches would discuss each point and then agree on its importance. The national coaches used their own judgement to identify each point.

Analysing the coaches' input

The coaches' descriptions of critical situations/errors were combined and the researcher classified them into categories that are the key performance indicators that prevent scoring opportunities.

Computer-based games analysis

For the second approach to data collection, the researcher went through each of the videotapes of the four games. Games analysis was completed, using technology in the form of the game analysis computer program, Netballstat, developed by the CSIR. Netballstat is a Windows win32 application, used to capture and analyse netball data to digital video and store it on a computer hard disk for random access retrieval. Most of the application has been written in Microsoft Visual Basic, with minor parts and certain components in C++. The hardware was a portable computer with a Pentium III 800MHz processor and 128MB RAM, manufactured by PC Planet in the United Kingdom. Video footage can be archived to a Panasonic DVD-RAM-disc (2.6GB capacity). The system uses a Miro DC30+ video capture card.

During a match a trained analyst can install the system at the court by mounting the digital video camera on the tripod and connecting it to the computer (Appendix B). This allows the analyst to provide "real-time" games analysis to a coach. Games analysis can also be done after the match because the game has been recorded on videotape. Each event

and action, throughout the game, is annotated and stored on the database, together with its time stamp. In this way, the coach or analyst can quickly search and view those parts of the game that are of interest. An action can be classified according to a menu of main events, for example, a centre pass. After classifying an action in an event category, the event can be categorised as successful or unsuccessful. When an event is classified as a centre pass, for example, and it is categorised as unsuccessful, the reason for the failure can also be noted. The reasons for unsuccessful events are regarded as key performance indicators.

The product of this computer-based games analysis, used in this study, was focussed on each time a team lost the ball and, according to the specific situation, the reasons why ball possession was lost. To complete the analysis, the researcher compiled the following summaries:

1. All the reasons for losing possession for every team for each quarter of each game.

2. The number of times a specific reason caused the loss of ball possession by every team during each quarter of each game.

3. The number of times ball possession was lost during each match by every team.

4. A total of the frequency of each reason for loss of ball possession by all teams in the course of the three matches.

The key performance indicators were then ranked according to the frequency over the three matches.

Additional game statistics

Computer-based technology was also used to generate additional match statistics. Every time a team had the opportunity to score a goal, because of ball possession, the researcher went and looked at whether the team could turn the possession into a goal. The researcher was able to generate statistical summaries for each game that included the total number of:

- Centre passes

- Turnovers
- Throw-ins
- Ball possession from open play, turned into goals

The statistics were gathered with the Netballstat program after the match.

Additional aspects of games analysis can be completed by hand. In order to provide a more detailed look at game play, relevant data can be entered on a recording sheet, such as the sheet developed by the New South Wales Department of Sport and Recreation (Australia) and J.S. Croucher (Croucher, 1997). This detailed look at a match was not used in this study, but is highly recommended for all coaches, more specifically for those who do not have access to a computer-based game analysis programme. A separate recording sheet is required for each quarter during the match. The information recorded, include the following:

- **General match information** (team, venues, etc.).
- **Minor infringements** (There are a number of minor errors that can occur, e.g. stepping, dropped ball, held ball, off side, break for centre pass and other technical infringements).
- **Major penalties** (Major penalties include contact and obstruction. With these events it can be marked whether the penalty occurred inside or outside the circle).
- **Results of toss-ups** (It is important to know which player was involved in a toss-up and in which third of the court the toss-up took place and whether it was won or lost).
- **Lost balls** (The reason for a lost ball can be either a bad throw or a bad catch and in some cases, both. The recorder has to make a subjective judgement).
- **Passing** (Every pass thrown during the match has to be recorded. Passes can be categorised into passes made throughout the match, the centre pass and a throw-in from the sideline).

- **The number of rebounds, deflections and interceptions** (The recording of this event indicates whether a player has been able to take a rebound or to intercept from the opposing team. It is also recorded whether a player was able to touch or tip the ball without gaining possession of the ball or whether the player was able to gain possession from the tip or deflection).

- **Detailed goal shooting details** (The goal shooting statistics record which player took the shot and from where in the goal circle; was it a long, middle or short shot; and was it successful or unsuccessful. The recorder has to make his/her own judgement about the position and length of the shot).

- **Possession gained from open play** (For many coaches, the number of times their team is able to convert unexpected possession during play into a goal is important. The unexpected possession can occur due to a mistake by the opposing team).

Summary

The following steps were followed in order to answer the research questions in this study:

1. Four expert coaches analysed game play of three top-level international netball matches in order to identify the reasons for success/failure during game play.

    a. The reasons for success/failure as identified by elite coaches were then grouped into categories of "key performance indicators".

2. A computer-based games analysis system was used to identify the reasons for losing ball possession during the same games analysed by the experts.

    a. The reasons for losing ball possession were accepted as key performance indicators. These key performance indicators were then ranked according to frequency.

3. A comparison was made between the critical indicators generated by the elite coaches and the critical indicators generated by the computer-based analysis.

4. Additional games statistics were generated, using games analysis.

The outcome of this research provided detailed information about the key performance indicators of a netball game, as well as a look at the contribution of games analysis to coaching netball.

Chapter 4

Results

The results are presented in relation to the four research questions that guided this study.

Research Question One

What are the critical indicators of success/failure in game play in netball, according to analysis by elite coaches?

According to the four elite coaches who analysed the videotapes of three elite games, the following can be considered as the critical indicators of success/failure:

1. Spatial awareness
2. Decision-making
3. Ball placement
4. Timing
5. Movement
6. Communication
7. Other:

   Body control

   Forced error

The coaches used the following descriptions of each of the indicators, usually when referring to a player who was "making a mistake."

Spatial awareness: The player without the ball is not aware of the open spaces available on court. She does not use the available space to move into, in order to receive a pass or to open up the court for another player.

Decision-making: The player has trouble identifying what needs to be done, e.g. she wrongly chooses to throw the ball or moves incorrectly.

Ball placement: A player makes a bad throw. The throw can be defined as too high, too low, too short or too far. A ball placement error is also defined as the ball changing possession or going out-of-bounds.

Timing: The ball is passed too early or too late, or the movement timing of the player without the ball who should receive the next pass is too early or too late.

Movement: The players who should be ready to receive the next pass do not plan ahead. No one makes a move to receive the next ball, which means the player with the ball does not have an option who to throw the ball to.

Communication: There is a misunderstanding between two players.

Other

- **Body control:** When a player with the ball does not have the necessary control over her body in order to stop on speed, balance and deliver an accurate pass.
- **Forced error:** When the opposition's defence is excellent and forces the team in possession of the ball to make an error.

These seven critical indicators were determined by taking all of the comments made by the coaches during their videotape viewing sessions, and grouping the comments into categories. This process is presented on the following page.

- WA and GA in same space, no attacking options
- No balance on court, all players on same side of court
- With centre pass, all the attacking players on same side to receive pass
- WA moves into wrong space, closes up space for GS

→ Over crowding space

- No option of who to throw to: GS out of goal circle, C and WA stood still on circle's edge, GA at the back of her defender
- WA and C, too early on circle's edge, do not provide space for shooters to move to

→ Move too early to create space

- When GS runs out of circle, too flat, not into space
- GS move is too flat out of goal circle
- Asking over passes at the back space
- Asked over pass for back space
- GS moves out of goal circle too flat
- Attacking players move to outside of court and not into space, stand still.
- No attacking player is creating space, after movement, stands still and do not clear

→ Move to wrong space

- GS does not defend her space, GK moves around and intercepts ball

→ Player did not defend her attacking space

→ **Spatial awareness**

- No definite attacking move from GS or GA that have to receive next pass
- GS is the obvious next pass, not alert enough. The GA stands still, also not ready for pass
- C receives ball under pressure, no option for next pass
- No movement on attack, all attacking players stand still
- No movement on attack, all players stand still, no planning
- On attack, no movement planning, unbalanced court
- WA and C stand still on circle's edge
- Opponents move to front of attacking players, attacking players stand still, no options

→ No anticipating movement

- Cannot feed ball into goal circle. GS and GA do not recognise situation and do not defend their space
- After the C had passed the ball, the player ran straight through other player's space
- After WD passes the ball, she runs straight through attacking player's space
- Drive to outside of court, opponents stay at inside
- C not available for square pass

→ Wrong movement

- The angle of attack is too flat.
- C just uses speed on attack
- Both shooters moved out of circle, to the same side
- Angle of attack is too flat
- GS moves with back away from ball
- No balance on court with throw-in

→ Attacking movement wrong

→ **Movement**

- GS positioning is good; WA forces the ball to GS
- GS out of circle, leaves GA with two defenders, passes to GA
- Pass to player with two defenders, wrong option
- Pass to player with two defenders

} Forcing the pass

- Long, diagonal pass, including four defenders, C was available
- Long diagonal pass at first throw of centre pass
- With the centre pass, wrong option of C, throw diagonal pass
- Wrong option, long, diagonal pass, instead of short pass

} Choose the diagonal pass option, rather than the shorter option

- GA "advertises" where the next pass is going, she throws too, wrong decision
- Wrong decision in centre third
- WA and GA at same side with centre pass, wrong decision by C
- Receives ball on speed, delivers ball to bad option

} Wrong decision

} **Decisionmaking**

- GA is not aware of space at her back; WA passes ball there. GA dodges and wants ball in front.

} **Communication**

- Bad pass to GS in goal circle
- Bad pass on centre pass
- Bad pass with centre pass
- WA unsuccessful pass to GS
- Ball placement too flat from GA to GS
- Bad pass from C to GA in goal circle
- C passes ball behind the WA
- Bad pass from C to GA in goal circle
- Bad pass from C to GA
- Bad pass to GS in goal circle
- C throws ball too high with centre pass
- Pass to shooter too flat
- Bad ball placement
- Bad pass from C to WD with centre pass
- Throws long pass, pass easily intercepted
- C passes ball to GS too high, in goal circle
- Bad ball placement from C to GA in centre third
- Pass to GS too short

Ball placement

- Timing of pass too late
- WA waits too long to pass to shooter
- C passes to slowly, defender has time to intercept
- C waits too long to pass ball to GA
- Timing of pass with centre pass too slow

Timing of the pass

- Timing of movement too early
- With centre pass, attacking players standing still until the last second.
- Timing of attacking too early, no player clear, standing still

Timing of movement

Timing

- The C receives the ball under pressure, does not have the body control to deliver a successful pass
- Catches, steps and throws, no body control to deliver next pass successfully

Body control

- Excellent defence leads to interception, forced error
- Lost ball in goal third, opponents force attacking players to outside of court – forced error
- Opponents force the first pass of the centre pass out of court – forced error
- Opponents defend the space and forced an error
- Force opponents to outside, force an interception
- Excellent defence in goal circle – forced error
- With throw-in from back, force the attacking players into corner, no option

Forced error

Other

Research Question 2

What are the critical indicators of success/failure in game play in netball, as identified by a computer-based games analysis system?

The computer programme used in this study focussed on the events that lead to or followed the loss of ball possession. The following is a list of the indicators associated with loss of possession, ranked according to frequency of occurrence:

Critical Indicator	Frequency of Occurrence
1. Ball placement	87
2. Decision-making	51
3. Miss shot	39
4. Bad catch	29
5. Contact	22
6. Breaking	17
7. Spatial awareness	14
8. Stepping	10
9. Movement	9
10. Other: forced error	8
11. Timing	7
12. Communication	5
13. Held ball	4
14. Off side	2
15. Over a third	1

This ranking was based on the identification of the reason for loss of ball possession on quarter-by-quarter game analyses of each of the teams involved in each of the three international matches. Table 1 and Table 2 present the data for the England vs. Australia match. Table 3 and Table 4 present the data for the South Africa vs. Australia match. Table 5 and Table 6 present the data for the South Africa vs. New Zealand match. Table 7 presents a summary of the data from all three matches.

Table 1. Computer-based games analysis of loss of ball possession in match one: England vs. Australia: England

England									
Factors	**Quarter 1**		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision-making	✓	1	✓	1	✓✓✓	3	✓	1	6
Miss shot		0	✓✓✓✓	4	✓✓	2	✓✓	2	8
Contact		0		0		0	✓	1	1
Stepping		0	✓	1		0		0	1
Ball placement	✓✓✓✓✓✓✓	7	✓✓✓✓✓✓	6	✓✓✓✓	4	✓✓	2	19
Bad catch		0		0	✓	1	✓	1	2
Spatial awareness		0	✓✓	2		0		0	2
Breaking	✓✓✓	3	✓	1		0		0	4
Held ball		0		0		0		0	0
Timing	✓	1		0		0		0	1
Off side		0		0		0		0	0
Over a third		0		0		0		0	0
Communication		0	✓	1		0		0	1
Movement		0		0		0	✓	1	1
Other	✓✓✓Defence	3		0		0		0	3
Total	15		16		10		8		49
Score	10		13		31		44		44

Table 2. Computer-based games analysis of loss of ball possession in match one: England vs. Australia: Australia

Australia									
Factors	**Quarter 1**		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision- making	✓	1	✓	1		0	✓	1	3
Miss shot	✓	1	✓✓✓✓	4	✓✓✓	3	✓✓✓	3	11
Contact	✓	1	✓	1		0	✓✓	2	4
Stepping	✓✓	2		0		0	✓	1	3
Ball placement		0	✓	1	✓✓	2	✓✓	2	5
Bad catch	✓	1	✓✓✓	3	✓	1		0	5
Spatial awareness	✓	1		0	✓✓✓	3		0	4
Breaking		0		0		0	✓	1	1
Held ball		0		0		0		0	0
Timing		0		0		0	✓	1	1
Off side		0		0		0		0	0
Over a third		0		0		0		0	0
Communication		0		0		0		0	0
Movement		0		0		0		0	0
Other		0		0	✓ Defence	1		0	1
Total	7		10		10		11		38
Score	20		12		31		54		54

Table 3. Computer-based games analysis of loss of ball possession in match two: South Africa vs. Australia: South Africa

South Africa									
Factors	**Quarter 1**		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision-making	✓✓✓	3	✓✓✓✓	4	✓	1	✓✓✓✓	4	12
Miss shot	✓	1	✓	1	✓✓	2	✓✓	2	6
Contact	✓✓	2		0	✓✓✓✓	4		0	6
Stepping		0		0	✓	1		0	1
Ball placement	✓✓✓✓✓	5	✓✓✓✓	4	✓✓✓✓	4	✓✓✓✓	4	17
Bad catch		0	✓✓	2	✓✓✓✓	4	✓✓✓	3	9
Spatial awareness	✓✓✓	3	✓	1		0		0	4
Breaking	✓	1	✓	1	✓	1	✓	1	4
Held ball	✓	1	✓	1		0	✓	1	3
Timing	✓	1	✓	1		0		0	2
Off side		0	✓	1		0		0	1
Over a third		0		0	✓	1		0	1
Communication	✓	1		0		0	✓✓	2	3
Movement	✓	1	✓✓✓	3		0	✓✓	2	6
Other		0		0		0		0	0
Total	19		19		18		19		75
Score	7		6		6		9		28

Table 4. Computer-based games analysis of loss of ball possession in match two: South Africa vs. Australia: Australia

Australia								
Factors	**Quarter 1**		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision-making	✓✓	2	✓✓✓	3	✓✓✓	3	✓	1	9
Miss shot	✓	1		0	✓✓	2	✓✓	2	5
Contact	✓	1		0	✓	1	✓	1	3
Stepping		0		0		0	✓	1	1
Ball placement	✓✓✓	3	✓✓✓✓✓	5	✓✓✓✓	4	✓✓✓	3	15
Bad catch	✓	1		0	✓✓	2	✓✓✓✓✓	5	8
Spatial awareness		0		0		0		0	0
Breaking		0		0		0		0	0
Held ball		0		0		0		0	0
Timing		0	✓	1		0		0	1
Off side	✓	1		0		0		0	1
Over a third		0		0		0		0	0
Communication		0		0		0	✓	1	1
Movement		0		0		0		0	0
Other		0		0		0		0	0
Total	9		9		12		14		44
Score	29		22		20		18		89

Table 5. Computer-based games analysis of loss of ball possession in match three: South Africa vs. New Zealand: South Africa

South Africa									
	Quarter 1		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision-making	✓	1	✓✓	2	✓✓✓✓✓	5	✓✓✓✓✓	5	13
Miss shot	✓	1	✓	1		0		0	2
Contact	✓✓✓	3	✓✓	2		0		0	5
Stepping	✓	1		0	✓	1		0	2
Ball placement	✓✓✓✓✓✓	6	✓✓✓✓✓✓✓	7	✓✓✓✓✓✓	6	✓✓✓✓✓	5	24
Bad catch	✓	1	✓	1	✓	1	✓	1	4
Spatial awareness	✓✓	2		0	✓	1	✓	1	4
Breaking	✓	1		0	✓	1	✓✓	2	4
Held ball		0	✓	1		0		0	1
Timing	✓	1		0	✓	1		0	2
Off side		0		0		0		0	0
Over a third		0		0		0		0	0
Communication		0		0		0		0	0
Movement	✓	1		0		0	✓	1	2
Other		0	✓fall	1		0		0	1
Total	18		15		16		15		64
Score	7		11		11		10		39

Table 6. Computer-based games analysis of loss of ball possession in match three: South Africa vs. New Zealand: New Zealand

New Zealand									
	Quarter 1		**Quarter 2**		**Quarter 3**		**Quarter 4**		**Total**
Decision-making	✓✓✓✓	4		0	✓	1	✓✓✓	3	8
Miss shot	✓	1	✓✓✓	3	✓✓	2	✓	1	7
Contact		0	✓	1	✓✓	2		0	3
Stepping	✓	1		0	✓	1		0	2
Ball placement	✓✓✓	3	✓✓	2		0	✓✓	2	7
Bad catch	✓	1		0		0		0	1
Spatial awareness		0		0		0		0	0
Breaking		0	✓✓	2	✓	1	✓	1	4
Held ball		0		0		0		0	0
Timing		0		0		0		0	0
Off side		0		0		0		0	0
Over a third		0		0		0		0	0
Communication		0		0		0		0	0
Movement		0		0		0		0	0
Other	✓ fall	1	✓jump in from outside	1		0	✓ step out of court	1	3
Total	11		9		7		8		35
Score	17		14		19		18		68

Table 7. Summary of loss of ball possession in three international matches

	Match one		Match two		Match three		Total
	England	Australia	South Africa	Australia	South Africa	New Zealand	
Decision-making	6	3	12	9	13	8	**51**
Miss shot	8	11	6	5	2	7	**39**
Contact	1	4	6	3	5	3	**22**
Stepping	1	3	1	1	2	2	**10**
Ball placement	19	5	17	15	24	7	**87**
Bad catch	2	5	9	8	4	1	**29**
Spatial awareness	2	4	4	0	4	0	**14**
Breaking	4	1	4	0	4	4	**17**
Held ball	0	0	3	0	1	0	**4**
Timing	1	1	2	1	2	0	7
Off side	0	0	1	1	0	0	**2**
Over a third	0	0	1	0	0	0	**1**
Communication	1	0	3	1	0	0	**5**
Movement	1	0	6	0	2	0	**9**
Other	3	1	0	0	1	3	**8**
Total	49	38	75	44	64	35	305
Score	44	54	28	89	39	68	322

Research Question Three

What is the relationship between the information generated by elite coaches and that generated by computer-based games analysis?

Eight critical indicators of success/failure were identified when the results of the coaches and the information generated by the computer-based games analysis system were combined. These factors were ranked in order of frequency of errors in the three games analysed:

1. Basic errors (124)
2. Ball placement (87)
3. Decision-making (51)
4. Spatial awareness (14)
5. Movement (9)
6. Other, i.e. body control and forced errors (8)
7. Timing (7)
8. Communication (5)

The process of combing the data from the two sources is presented in Figure 1. All additional factors such as MS, C, S, B, HB, OS, OT were put together to form the basic errors. Basic errors occur during a game and a coach normally does not pay attention to them. These factors normally turn into a free or penalty pass during a game. In order to combine the data provided by the coaches with the data generated by the computer games analysis programme, the following abbreviations were used:

KPI	Key performance indicator
BP	Ball placement
DM	Decision-making
SA	Spatial awareness
O	Other
T	Timing
M	Movement
CM	Communication
MS	Miss shot
BC	Body control
C	Contact
S	Stepping
B	Breaking
HB	Held ball
OS	Offside
OT	Over a third

Identified key performance indicators

1. Spatial awareness
2. Decision-making
3. Ball placement
4. Timing
5. Movement
6. Communication
7. Other

Body control

Forced error

Ranking order of lost ball possession factors

1.	Ball placement	87
2.	Decision-making	51
3.	Miss shot	39
4.	Bad catch	29
5.	Contact	22
6.	Breaking	17
7.	Spatial awareness	14
8.	Stepping	10
9.	Movement	9
10.	Other: forced error	8
11.	Timing	7
12.	Communication	5
13.	Held ball	4
14.	Off side	2
15.	Over a third	1

1.	BP	87
2.	DM	51
3.	SA	14
4.	M	9
5.	O	8
6.	T	7
7.	CM	5

Basic errors 124

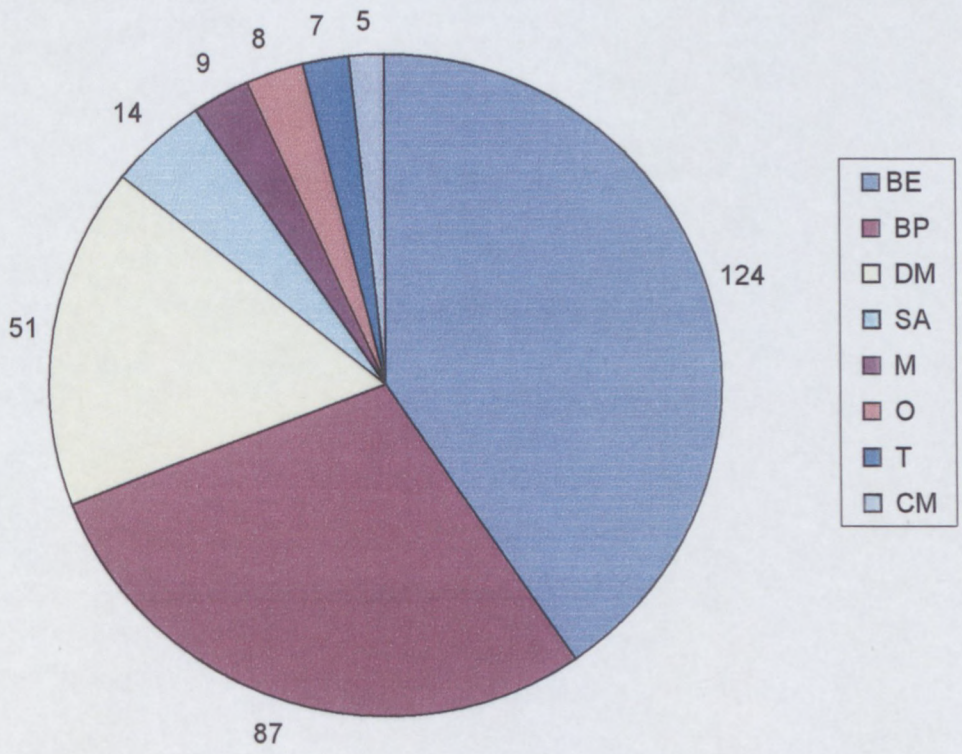
1.	MS	39
2.	BC	29
3.	C	22
4.	B	17
5.	S	10
6.	HB	4
7.	OS	2
8.	OT	1

1.	BE	124
2.	BP	87
3.	DM	51
4.	SA	14
5.	M	9
6.	O	8
7.	T	7
8.	CM	5

Figure 1

The relationship between the critical indicators identified by elite coaches and the computer-based games analysis system

Table 8. The frequency of the identified key performance indicators



Research Question Four

What additional game statistics can be generated, using games analysis?

The computer-based games analysis programme is capable of producing additional statistics that can provide valuable information to the coach. The following basic match statistics were generated as part of this study:

Turnover: When ball possession turns from the opposition to the other team by an interception or a rebound.

Throw-in: When ball possession changes from the opposition to the other team of a throw-in from outside the court. The opposition loses the ball by passing or touching it outside the court.

Centre pass: The number of times a team is able to convert their centre pass into a goal.

Open play: The number of times a team is able to convert unexpected possession during play into a goal is important. The unexpected possession can occur due to a mistake by the opposing team.

Table 8 and 9 present the additional game statistics for match one: England vs. Australia. Table 10 and 11 present the additional game statistics for match two: South Africa vs. Australia. Table 12 and 13 present the additional statistics for match three: South Africa vs. New Zealand.

Table 9. Additional game statistics produced by computer-based games analysis in match one England vs. Australia: England

England										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total percentages	
Turnovers	¾	75,00%	4/6	66,67%	3/5	60,00%	2/3	66,67%	12/18	66,67%
Throw-ins	1/1	100,0%	2/3	66,67%	0/3	00,00%	2/4	50,00	5/11	45,45%
Centre pass	4/15	26,67%	4/11	36,36%	8/13	61,54%	9/11	81,82%	25/50	50,00%
Open play	¾	75,00%	2/3	66,67%	2/2	100,0%	4/4	100,0%	11/13	84,62%
Total	11/24	45,83%	12/23	52,17%	13/23	56,52%	17/22	77,27%	53/92	57,61%

Table 10. Additional game statistics produced by computer-based games analysis in match one England vs. Australia: Australia

Australia										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total percentages	
Turnovers	6/7	85,71%	3/4	75,00%	3/7	42,86%	1/2	50,00%	13/20	65,00%
Throw-ins	2/3	66,67%	4/5	80,00%	2/4	50,00%	1/2	50,00%	9/14	64,29%
Centre pass	9/15	60,00%	6/11	54,55%	9/14	64,29%	7/12	58,33%	31/52	59,62%
Open play	3/4	75,00%	1/4	25,00%	0/0	00,00%	4/4	100,0%	8/12	66,67%
Total	20/29	68,97%	14/24	58,33%	14/25	56,00%	13/20	65,00%	61/98	62,24%

Table 11. Additional game statistics produced by computer-based games analysis in match two South Africa vs. Australia: South Africa

South Africa										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total	
Turnovers	1/2	50,00%	3/10	30,00%	1/8	12,50%	1/5	20,00%	6/25	24,00%
Throw-ins	0/2	00,00%	1/3	33,33%	2/5	40,00%	8/14	57,14%	11/24	45,83%
Centre pass	6/18	33,33%	4/15	26,67%	6/13	46,15%	8/14	57,14%	24/60	40,00%
Open play	2/4	50,00%	0/0	00,00%	1/1	100,0%	0/2	00,00%	3/7	42,86%
Total	9/26	34,62%	8/28	28,57%	10/27	37,04%	17/35	48,57%	44/116	37,93%

Table 12. Additional game statistics produced by computer-based games analysis in match two South Africa vs. Australia: Australia

Australia										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total percentages	
Turnovers	8/9	88,89%	9/14	64,29%	6/11	54,55%	7/15	46,67%	30/49	61,22%
Throw-ins	2/3	66,67%	1/2	50,00%	0/0	00,00%	0/0	00,00%	3/5	60,00%
Centre pass	18/18	100,0%	12/14	85,71%	13/13	100,0%	13/14	92,86%	56/59	94,92%
Open play	3/4	75,00%	3/4	75,00%	4/7	57,14%	1/2	50,00%	11/17	64,71%
Total	31/34	91,12%	25/34	73,53%	23/31	74,19%	21/31	67,74%	100/130	76,92%

Table 13. Additional game statistics produced by computer-based game analysis in match three South Africa vs. New Zealand: South Africa

South Africa										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total percentages	
Turnovers	2/8	25,00 %	0/3	0,00 %	1/4	25,00%	0/2	0,00 %	3/17	17,65%
Throw-ins	1/2	50,00 %	1/4	25,00 %	0/4	0,00 %	1/3	33,33%	3/13	23,08%
Centre pass	6/13	46,15%	8/13	61,54%	10/15	66,67%	10/15	66,67%	34/56	60,71%
Open play	1/1	100,0%	3/4	75,00%	0/3	0,00 %	1/2	50,00%	5/10	50,00%
Total	10/24	41,67%	12/24	50,00%	11/26	42,31%	12/22	54,55%	45/96	46,88%

Table 14. Additional game statistics produced by computer-based games analysis in match three South Africa vs. New Zealand: New Zealand

New Zealand										
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total percentages	
Turnovers	1/3	33,33%	2/3	66,67%	5/7	71,43%	5/7	71,43%	13/20	65,00%
Throw-ins	5/7	71,43%	2/7	28,57%	3/3	100,0%	2/2	100,0%	12/19	63,16%
Centre pass	11/12	91,67%	10/13	76,92%	14/16	87,50%	15/15	100,0%	50/56	89,29%
Open play	1/4	25,00%	1/2	50,00%	1/2	50,00%	1/2	50,00%	4/10	40,00%
Total	18/26	69,23%	15/25	60,00%	23/28	82,14%	23/26	88,46%	79/105	75,24%

Conclusion

The outcome of this study is the identification of the critical indicators of success/failure in top-level netball. This information is important for the design of training sessions that will prepare players to compete at the international level. The results of this study also demonstrates that computer-based games analysis could provide additional insight into the patterns of play that lead to loss of ball possession in a game, and that it could serve as helpful general game statistics.

Chapter 5

Discussion

In order to stay competitive in a very competitive environment, it is important that the coach and the team pay more attention to both the technical and tactical side of their sport. Through the use of technology, games analysis can be supportive of the process of doing exactly this, and thus be of great help.

A major problem for coaches is to identify those game elements that lead to successful and unsuccessful performance. In order to create and prevent scoring opportunities, coaches have to identify these elements or "critical indicators" of performance (Hughes & Franks, 1997). In an attempt to overcome this problem, games analysis systems have been developed. In invasion games like netball, a large number of indicators that can influence the result of a game. With reference to the literature, the most important aspect of invasion games is to maintain ball possession in order to score (Hughes, 1997). To prevent the loss of ball possession, the reasons for the loss of ball possession have to be identified first.

This study initially used expert coaches to identify the key performance indicators. By means of computer-based technology, i.e. a games analysis system, the exact number of the lost ball possession factors were identified and prioritised. This additional information produced by the system demonstrated that technology could complement the input of expert coaches and support coaching decisions. The extra factors that were identified via the use of technology can be categorised as basic errors, which lead to either a free pass or a penalty pass during a game. During the match, the coach normally does not pay much attention to these factors, but he/she can use the statistics after the game. Statistics obtained during a match will show a team their strengths and weaknesses. Practice can then be designed to overcome the weak areas of play and to emphasise the strong areas of play. The results of this study clearly support the position presented by Crouch (1992), who stated that a comprehensive analysis of performance could identify the critical sources of success and failure.

Computer generated games analysis can also provide the video clips for each unsuccessful action, which include all the basic errors. The use of these video clips is

particularly helpful in planning practice sessions and preparing for future games. A coach cannot give a great deal of input to players during a netball game. The players on court have to think for themselves and make their own decisions. Video clips from previous games, can help coaches during practice sessions to develop thinking players to help them learn to avoid the loss of ball possession. Technical and tactical coaching can be directed toward the highest probability events. The coach could then, during coaching sessions, direct the team toward a more winning profile.

The Four Most Frequent Critical Performance Indicators (KPIs)

The following section presents the four critical performance indicators that occurred most frequently during the international matches analysed in this study.

1. **Basic errors**

   Basic errors are the major factors leading to loss of ball possession. Basic errors include poor skill execution that can be practiced beforehand and therefore rectified. Basic errors are regarded by coaches as unnecessary errors that occur during critical moments in the match, sometimes without any player touching the ball, as is the case with breaking. On a top level, coaches are supposed to spend less time preventing these errors. Top-level skill execution is supposed to be automated. But if these errors are made, practice sessions must be changed to address this problem. For example, a team may show superb skills and tactical court play, but unless the shooters can accurately score goals, the effort will be wasted. If the shooters are unable to score, this has to become the focus of their practice sessions.

2. **Ball placement**

   According to Griffen, Mitchell & Oslin (1997), improved game performance is the result of increased tactical awareness. They defined tactical awareness as the ability to identify problems and their solutions in the necessary game situations. Ball placement is a function of tactical awareness, and was the second most frequently occurring critical indicator. Tactical game performance is closely related to skill performance, but involves much more than that. Ball placement

has to be practiced. Practice sessions, combing skill execution and game tactics, provide the forum to apply game-related skills and improve, among other aspects of play, ball placement.

3. **Decision-making**

   The structure of netball is based on relationships between individuals, team-mates, and the opposition. This is why tactics and decision-making are important components of performance. For players on the top-level, tactics and decision-making should be a natural product of excellent body control, ball control, space, communication and knowledge of the game. Decision-making in team sports is the ability to make quick and accurate tactical decisions and is one of the most important aspects of performance.

4. **Spatial awareness**

   Players must have the ability to close down space and prevent scoring, or open up space for team-mates to score. Decisions are based upon the principles of space and time, which are connected to the movement of the ball and the players. Practice sessions that incorporate work with spatial awareness should help reduce errors associated with this critical indicator.

It should be noted that each match in netball is unique, played under its own circumstances and against different teams. This is also the case with the three matches used for data gathering in this study. With that in mind, the following observations can be made of each match.

Match one: England vs. Australia

Key performance indicators

England		Australia	
1. Ball placement	19	1. Basic errors	24
2. Basic errors	16	2. Ball placement	5
3. Decision-making	6	3. Spatial awareness	4
4. Other	3	4. Decision-making	3
5. Spatial awareness	2	5. Other	1
6. Movement	1	6. Movement	0
7. Timing	1	7. Timing	0
8. Communication	1	8. Communication	0

- Australia's first ranked KPI, basic errors score, was much higher than England's, the main reason for this being missed shots and bad catches.
- Secondly, the ball placement errors of England were much higher than those made by Australia. The reason for this can possibly be because England had difficulty handling the pressure in the game, or that players were not able to think quickly enough on court.
- England's decision-making errors were also higher than Australia's.
- Australia's spatial awareness errors were similar to England's.
- The remaining KPIs indicate that England made more mistakes leading to the loss of ball possession more than Australia, the winning team, did.

Quarter 1

- Australia made fewer errors than England during quarter one; therefore Australia's first quarter score was higher: 20 vs. 10.

- England's highest error score was ball placement, and they made unnecessary basic errors, e.g. breaking, that could be prevented.

- Australia had more ball possession opportunities, because England made more mistakes during the game. England had a very bad centre pass possession percentage. Just by increasing their centre pass possession percentage their quarter possession percentage could have increased. During quarter one, again Australia supported the increase of the importance of ball possession.

Quarter 2

- During quarter two Australia made fewer errors, but England won the quarter 13 vs. 12. The reason can be due to the fact that Australia missed several shots.

- Ball possession opportunities for both teams during this quarter were similar. Australia's ball possession for the quarter was higher than England's, but England's centre pass possession increased over the first quarter. Overall, England's ball possession percentage increased. This caused England's score to increase in this quarter.

Quarter 3

- The error scores of both teams were the same during quarter three. The basic errors of England decreased, which had an important impact on the quarter error score. Australia won the quarter 13 vs. 8, despite the fact that England's error score decreased.

- Australia kept using their ball possession; so their ball possession percentage was still constant, with a high centre pass possession percentage.

England's centre pass possession percentage increased during quarter three. England cut out many errors during quarter three.

Quarter 4

- England won quarter four, 13 vs. 9. The main reason for this could be because the errors during quarter 4 were less and that England had a much higher ball possession percentage score during this quarter.

- England's centre pass possession percentage was excellent and higher than that of Australia. For the first time during the match, England had more ball possession opportunities, because they kept their error score low. Australia made more errors than in quarter three.

Conclusion

- During the match England decreased their number of errors with every quarter and increased their centre pass possession percentage in order to increase their total ball possession percentage by the end of the game. This can be described as an excellent sign, because from quarter one, England tried to prevent and cut out the basic errors. Unfortunately, the gap in score, created during quarter one, was too great to overcome.

- On the other hand, Australia's error and quarter scores were almost the same throughout the match. That reflects a constant team with a constant ball possession and centre pass percentage from the beginning of the match to the end. If Australia could prevent the many missed shots that increased their basic errors, they would have had a higher game score.

- England had higher scores in KPI, which means that coaches still have to do a lot of work to develop more thinking players in order to prevent basic errors.

- The after-game summary for each coach would look something like this:

  Most prominent identified needs

  England:

1. Ball placement
2. Basic errors
3. Decision-making

Australia:

1. Basic errors, such as shooting

These are the aspects the coaches have to pay attention to during the next training session. The coaches can look at the video clips and specifically pay attention to what is happening during the game. Each coach has to try to use the game sense approach to correct these KPIs. This approach not only helps players to perfect the motor skills needed for game performance (Turner & Martinek, 1999), but also to develop, within them, a better understanding of the rules and tactics.

Match two: South Africa vs. Australia

Key performance indicators

South Africa		Australia	
1. Basic errors	31	1. Basic errors	18
2. Ball placement	17	2. Ball placement	15
3. Decision-making	12	3. Decision-making	9
4. Movement	6	4. Communication	1
5. Spatial awareness	4	5. Timing	1
6. Communication	3	6. Spatial awareness	0
7. Timing	2	7. Movement	0
8. Other	0	8. Other	0

- Both teams' basic errors scores were very high. South Africa made many bad catching errors, and missed many shots and contact, which could have been

prevented. The fact that they had a few held ball errors was the result of excellent defence by Australia that left no movement options for South Africa on court. That also explains why the score of the movement error is not very high.

- The reason for the high basic error score for the Australian team was missed shots and bad catches.
- Both teams' ball placement errors were high.
- South Africa's decision-making score was higher than Australia's. Errors in spatial awareness were also higher than that of the winners, Australia.
- The rest of South Africa's (the losing team) ranked errors were higher than Australia's (the winning team).

Quarter 1

- The South African team made many more errors than the Australian team during quarter one and could not keep ball possession. The scores of the basic errors and ball placement were higher, and the ball possession score was very poor.
- The Australian team had an excellent ball possession score and a 100% centre pass possession percentage, with only a few faults in play.
- The result was a big difference in the quarter score with Australia leading with 29 vs. 7. The Australian team had more ball possession opportunities during quarter one.

Quarter 2

- During quarter two both teams' error scores were the same as in the previous quarter. The difference in quarter scores, however, decreased.
- Both teams' ball possession percentage decreased, but the Australian team's score was still within a very high range. This was the South African team's worse quarter of the match.

- The reason for the smaller difference in the quarter score can be attributed to the lower ball possession percentage of Australia; the South African team did not play better during this quarter. Australia still had more ball possession opportunities than South Africa.

Quarter 3

- During quarter three the Australian team had a small increase in their error score. Again, there was a smaller difference in the quarter score between the two teams.

- South Africa's centre pass possession percentage showed an increase, as was the case with overall ball possession. Their error score also decreased.

- The basic errors score of the South African team was still very high, because of unnecessary contact.

- Australia had, once again, an excellent centre pass possession of 100%. Both teams had the same amount of ball possession opportunities during quarter three. The Australian team made much better use of their opportunities.

Quarter 4

- The Australian team's errors increased, more specifically the basic error score, because of bad catches. The South African team's errors remained the same.

- The fourth quarter score difference was the smallest of all four quarters. The result of this can be ascribed to the fact that the South African team's ball possession percentage looked better, more specifically the centre pass ball possession percentage. This was the only quarter in which the South African team had more ball possession opportunities than the Australians.

Conclusion

- Both teams had a problem with ball placement during the game. South Africa could not decrease their placement errors during the game, and results remained

constant during each quarter. Australia had a small increase in error score. There was a decrease in the difference in scores in each quarter.

- Australia played a dominant game with a few basic errors. Their centre pass possession percentage was excellent throughout the game. When South Africa increased their ball possession percentage they scored more often, but they could not prevent their basic errors.

- South Africa committed the most basic errors as well as the most KPI errors. Perhaps the players were not ready to play such a competitive match and handle that type of pressure. Their basic skills execution did not support their game plan. In order to cut out KPI errors coaches first have to pay a lot of attention to basic errors, and then start developing thinking players.

- The South African team's ranked list of KPIs largely matched the identified ranking order of KPIs in this study. Australia's ranking order differed slightly. The Australian team did not have such a big problem with the KPIs, but the coach could try to prevent the unnecessary errors and pay more attention to ball placement in coaching sessions. The South African team did well during the last quarter.

- The total average ball possession percentage for each quarter for the two teams was the closest during quarter four. Perhaps the South African team became more relaxed, or maybe the Australian team became too relaxed!

- After a game a summary can be prepared for the coach:

  Most prominent identified needs

  South Africa:

  1. Basic errors
  2. Ball placement
  3. Decision-making

Australia:

1. Basic errors, such as shooting
2. Ball placement
3. Decision-making

These are the aspects the coach has to pay attention to during the next training session. The coach can look at the video clips and specifically pay attention to each game situation. Therefore, the coach could plan which specific areas of play the team has to work on. The coach has to try and use the game sense approach to correct these KPIs. By watching the video clips the coach can see exactly which player(s) can be associated with the KPI, where on court it happened and what the consequence was.

Match three: South Africa vs. New Zealand

Key performance indicators

South Africa		New Zealand	
1. Ball placement	24	1. Basic errors	17
2. Basic errors	18	2. Decision-making	8
3. Decision-making	13	3. Ball placement	7
4. Spatial awareness	4	4. Other	3
5. Movement	2	5. Spatial awareness	0
6. Timing	2	6. Movement	0
7. Other	1	7. Communication	0
8. Communication	0	8. Timing	0

- The South African team had higher scores than New Zealand for both its first and second KPI's. This means they made more errors that led to loss of ball possession.

- The South African team's missed shots score was less than that of the New Zealand team. But South Africa had a high basic error score due to high incident of contact as well as breaking.
- The rest of the South African's scores were higher than New Zealand's, the winning team.

Quarter 1

- South Africa's error score during quarter one was high, especially the basic errors. The basic errors were much higher than New Zealand's.
- There were more or less equal ball possession chances for both teams.
- New Zealand had a much higher ball possession percentage than South Africa, especially with the centre passes, which led to a higher quarter score than South Africa, 17 vs. 7.

Quarter 2

- Quarter two's scores were the closest.
- New Zealand's basic errors were the highest in this quarter, which could be connected to more missed shots. Both teams made fewer errors, with an increase in the ball placement factor for South Africa.
- The South African team's ball possession was higher; therefore the score was closer. The centre pass possession of South Africa was higher than in the previous quarter and the New Zealand team's centre pass percentage was lower than in the previous quarter. Both teams had similar ball possession opportunities. During quarter two the teams' average ball possession percentages for the quarter were the closest to each other. Both teams made fewer errors and more use of ball possession opportunities.

Quarter 3

- The New Zealand team's errors decreased. Basic errors formed the biggest part of this score. The South African team's basic errors decreased.

- The difference in the quarter score became bigger.
- The New Zealanders experienced a decrease in their error score and their ball possession percentage was excellent. They used every ball possession opportunity. The centre pass possession percentage of the South African team increased.

Quarter 4

- New Zealand's basic error score was down to a minimum. South Africa's ball placement and decision-making errors were still very high.
- New Zealand had more ball possession opportunities and used every opportunity. They had an excellent ball possession percentage, the highest of all four quarters. During quarter four, South Africa had the highest ball possession percentage, as well as the highest centre pass percentage of all four quarters that led to an increase in the total ball possession percentage.

Conclusion

- New Zealand's errors decreased from quarter one to quarter four, which provided a better ball possession opportunity that the team used excellently.
- The amount of errors made by the South Africans stayed the same during the match.
- Quarter two was South Africa's best quarter, with fewer errors and a higher ball possession percentage.
- Both teams had the highest ball possession percentages in the last quarter, both teams kept ball possession and the number of errors as low as possible.
- The South African team definitely has to pay attention to ball placement. New Zealand has to try to prevent the basic errors in order to keep more ball possession. New Zealand had more ball possession opportunities throughout the match because of the many errors of the South African team. The South African team's coach had to observe which players could not prevent the basic errors during the match, and take them off after the quarter. During the match the coach

had to focus attention on preventing basic errors in order to keep more ball possession. Both teams' coaches can focus on this, in other words, to minimize the KPIs of ball placement and decision-making by developing thinking players.

- After a game a summary can be prepared for the coach:

  Most prominent identified needs

  South Africa:

  1. Ball placement
  2. Basic errors
  3. Decision-making

  New Zealand:

  1. Basic errors
  2. Decision-making
  3. Ball placement

  These are the aspects the coach has to pay attention to during the next training session. The coach can look at the video clips and specifically pay attention to each game situation. Therefore the coach can plan which specific areas of play the team has to work on. The coach has to try to use the game sense approach to correct these KPIs.

Comparison between the three matches

Each game is played under its own special circumstances, so care must be taken in making direct comparisons. However, general conclusions can be made, based on the games analysis.

- During match one, between England and Australia, the score was closer; therefore the error score was lower and closer. Both teams made relatively few

errors. The differences between the error score and the match score were both close. In comparison with the scores of the other two matches; the closer the match score, the fewer errors were made. The ball possession percentages during match one were also closer to each other, with final average ball possession percentages of 57,61% and 64,24%.

- During match two between South Africa and Australia, there was a huge difference in error score, 31, and in the final match score, 61. In comparison with match one, the bigger the difference in the score, the greater the number of errors, because of the losing team making so many errors. The total number of errors during the match was greater than the total amount of shots scored during the match. When a losing team is under pressure and their options become less during the match, they play a lot of short passes or passes to the back, because they have no other option. Therefore, the greater the number of passes incurred, the greater the opportunity for the defenders to break the attack and intercept. Australia had many turnover opportunities, which they used well. In comparison with game one, there is a huge difference in the average ball possession percentages. Australia had an average ball possession percentage of 76,92% for the game, and South Africa 37,93%. Therefore, if the difference in score is very high, the difference in ball possession percentage will also be high.

- During match three between South Africa and New Zealand, the difference in error score was also high, 31, but the difference in match score was not so high compared to match two, 31. The reason for that can be ascribed to the fact that the average ball possession percentages were closer than in match two, South Africa 46,88% and New Zealand 75,24%. Both teams made better use of the ball possession opportunities compared to match two. Again, the ball possession percentages were not so good, if compared to match one, but the score was not as close as in match one.

According to Fairs (1987), when planning the next practice session or season, each coach has to take into account his/her team's strong areas and try to build on that. The coach also has to point out the weak areas in order to work on them. This is where games analysis becomes complex, because the coach and his/her team also have to take the opposition's game tactics into account, as well as build their own game plan and tactics.

Only by working in a dynamic way teams can reach their full potential (Launder & Piltz, 1999).

The difficulties experienced by the South African team throughout the two matches were that their basic skills and tactics were not strong enough to sustain effective game play. They could not cope with such strong competition. According to the literature review (Abernethy in Pyke, 1997), the skilled player can read and react accurately under pressure in an unhurried way. Games analysis leads to the recommendation that South Africa focus on the basic areas of play within a games sense approach. A games analysis system can only help them to identify their errors. On the other hand, the Australian and New Zealand teams' basic skill and tactics levels were very high and they can spend time to focus on their opponents' game plan and tactics, as well as their own.

Summary

The results of this study demonstrated that computer-based games analysis can help identify critical indicators in netball, as well as provide additional statistics that are of value for providing players and coaches with feedback. The use of a games analysis system also allows a more in-depth analysis of the critical performance indicators that determine success/failure in top-level netball.

A coach or analyst can use a basic notation system to gather performance data of individual players or a team. The coach can then assess the strengths and weaknesses of the individuals and the team, or that of their opponents, and will be able to make an attempt at correcting them. This type of system can be adapted very easily for any team sport.

Chapter 6

Conclusion and Recommendations

In this last chapter a general discussion of the conclusion and recommendations for future research will be given. The problems experienced and possible shortcomings of the study will be highlighted.

Discussion

The purpose of this study was to determine the key performance indicators in a netball game, which can be related to the main reasons for unsuccessful or successful performance. The main principle in invasion games like netball is to keep ball possession.

Firstly, the four expert coaches helped to identify the indicators. A computer-based program, games analysis with a notation system, had been devised for the analysis of lost ball possession. During a game the eight key performance indicators had a big influence on the result of the game. A computer-based games analysis program provides quality feedback to the coach and players and a broader spectrum of research.

Conclusion

The following conclusions about top-level netball can be drawn, based on the results in this study:

1. The team that made fewer faults and kept ball possession won the match.
2. The losing team's total identified key performance indicators score was the highest.
3. Each quarter's scores were indicative of how the score of each quarter errors outnumbered the score of the losing team, and that the leading team's error score

was much lower than the winning team's score, even if you added each quarter's time score.

4. A comparison can be made between the increase of the error score from the losing team during a quarter on the one hand, and the increase of the quarter score of the winning team on the other.

5. The total number of mistakes during a game have a definite influence on the outcome of the result of the game.

6. Expert coaches are necessary for effective coaching and should:

    - Have the knowledge to develop the instructional task that is well organised.
    - Be able to organise and collect the necessary information about previous performance and opponent performance, and to give the appropriate feedback.
    - Be able to develop thinking players and know how to obtain successful results.
    - Be able to state the purpose, objectives for the practice session.
    - Be able to communicate effectively to explain and instruct the skills and/or the tactical game plan clearly.

Problems and shortcomings

- Difficulty was experienced to get hold of coaches for a long enough period, in order to analyse the videos in detail.
- Not all the coaches had previous experience in the field of games analysis.
- Some coaches had difficulty with firstly identifying, and then solving the problem effectively.

Recommendations

The data from this study could be used for further studies:

1. How coaches can prevent key performance indicators through specific coaching.
2. The training of coaches in the use of games analysis, and how to interpret the information.
3. Using the key performance indicators as parameters in a games analysis program can develop the programs further.
4. To test the increase in performance for a team that is using a games analysis system over a period of time.

Prior to this study, computer-based games analysis pointed out main events and then subdivided these events into successful and or unsuccessful events. In addition to this, it also provided more specific notational information about team play (Appendix C). Video clips could be provided of each event.

This study serves as an extension of the computerised games analysis programme referred to in the study. The contribution is in the form of the identified key performance indicators that explain and specify the unsuccessful events during a netball match.

The researcher interviewed Jean Searle (2001), the South African coach during the 2001 Trinations series in Australia. Her opinion was that the games analysis system, combined with a match or game analyst (the researcher), is of great importance and use to a team, because of the useful information that it provides. It relieves some of the pressure on the coach, because of time constraints on the coach and the many roles that he/she has to fulfil.

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Appendix A

The essential information of netball

A netball team consists of seven players. Each player has a limited area, and a specific role allocated to her in the area that the player has to operate. The basic rules of netball include the following (Hughes & Franks, 1997):

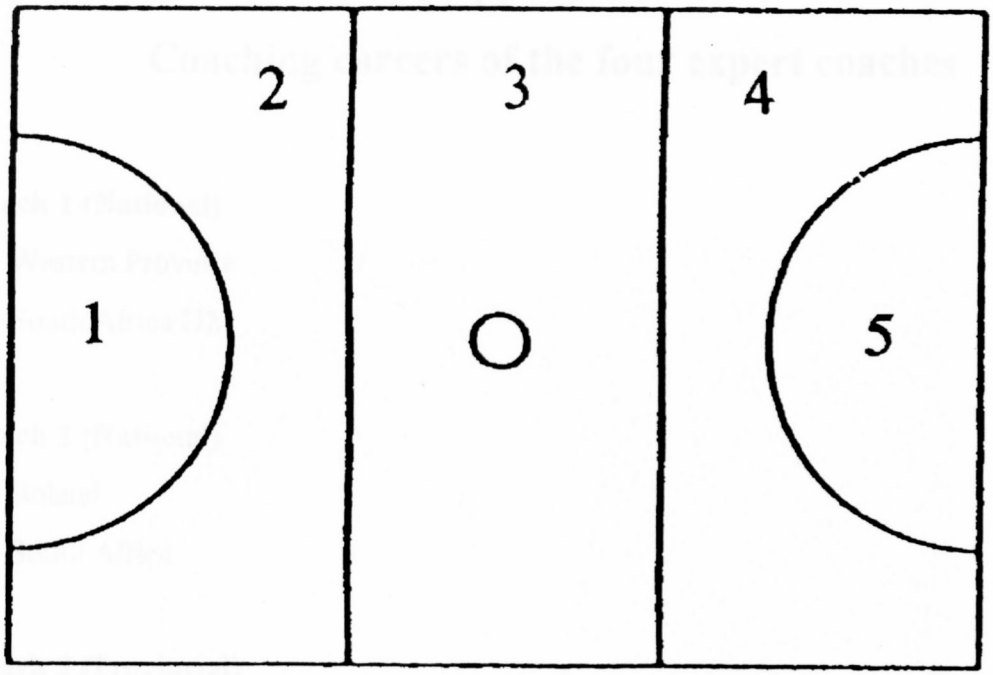
1. There is a three second limit on the time it takes a player to pass the ball or attempt a shot at goal.
2. The ball must be caught or touched in each third of the court during play.
3. The centre pass must be caught or touched by a player allowed in the centre third of the court.
4. Only the goal-shooter or goal-attack can score a goal. The ball must also have been wholly caught within the goal circle.
5. A player must keep within the limits of the area prescribed by her position (p.131).

During the game each player on court wears a vest with letters representing their position on court:

GK	goal-keeper
GD	goal defense
WD	wing defense
C	centre
WA	wing attack
GA	goal attack
GS	goal shooter

The court is divided into areas in which some players may play.

GK	goal circle & goal third
GD	goal circle, goal third & centre third
WD	goal third & centre third
C	goal third, centre third & goal third
WA	goal third & centre third
GA	goal circle, goal third & centre third
GS	goal circle & goal third



- 1. Goal circle
- 2. Goal third
- 3. Center third
- 4. Goal third
- 5. Goal circle

Appendix B

Coaching careers of the four expert coaches

Coach 1 (National)

- Western Province
- South Africa U21

Coach 2 (National)

- Boland
- South Africa

Coach 3 (Provincial)

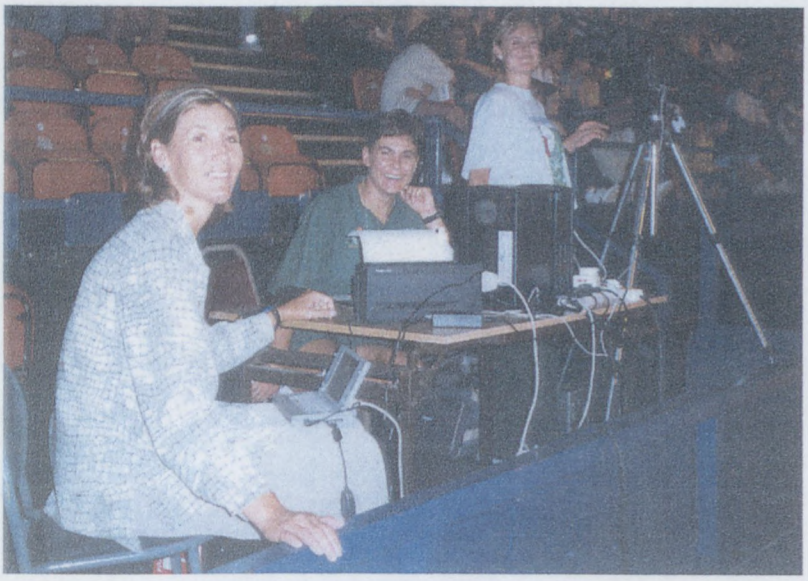
- Boland

Coach 4 (Provincial)

- Boland

Appendix C

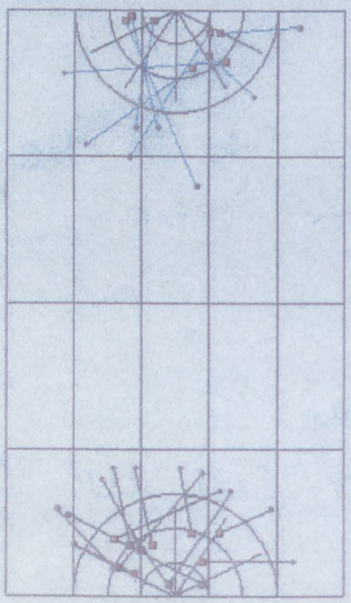
"Real-time" games analysis



During a game a trained analyst (in the middle of photo) install the system at the court by mounting the digital video camera on the tripod (right) and connecting it with the computer. This allows the analyst to provide "real-time" games analysis to a coach (left on the photo).

Appendix D

Additional computer-based games analysis information



Team1 = U21 South Africa (att. North)
Team2 = England (att. South)
From : 13/05/2000
To : 13/05/2000
Event : Circle entry
The event was : Goal

Successful event
Unsuccessful event
U21 South Africa attacking
England attacking
U21 South Africa turnover
England turnover

Quart	U21 GL	U21 CE	ENG GL	ENG CE	U21 %	ENG %
1st	6	12	14	32	50	63
2nd	5	16	9	19	31	69
3rd	9	13	11	18	69	61
4th	8	16	16	20	50	80
Total	28	57	50	73	49	68

Team1 = U21 South Africa (att. North)
Team2 = England (att. South)
From : 13/05/2000
To : 13/05/2000
Event : Circle entry
The event was : Unsuccessful